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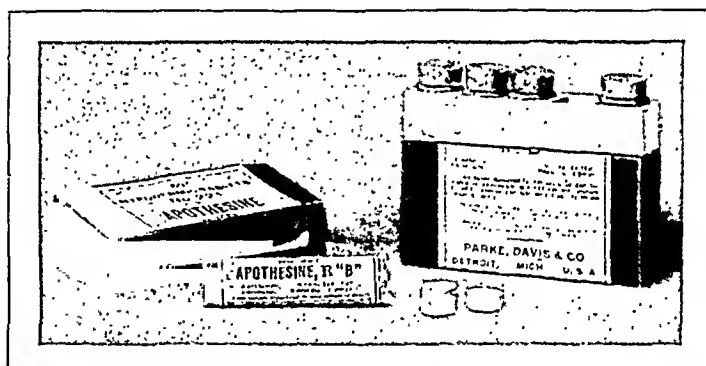
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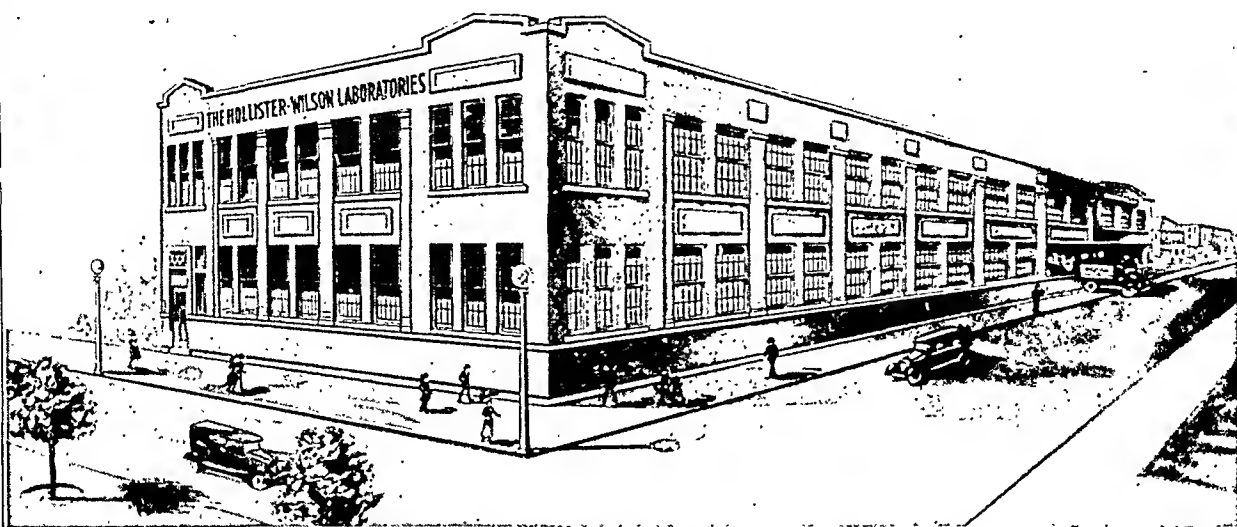
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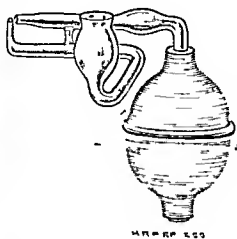
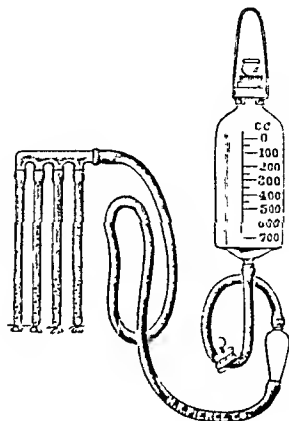
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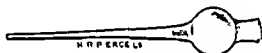


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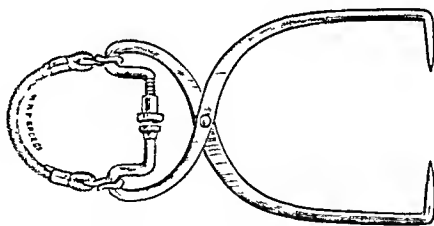
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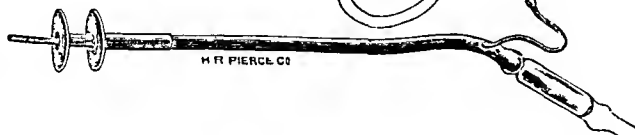
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ANNALS *of* SURGERY

VOL. LXX

JULY, 1919

No. 1

CRANIOPLASTY. THE VALUE OF A GRAFT OF BONE, CARTILAGE OR FASCIA IN THE CLOSURE OF CRANIAL DEFECTS CAUSED BY WOUNDS IN WAR *

A STUDY OF THE RESULTS OBTAINED IN A SERIES OF FORTY-TWO OPERATIONS

By ALEXANDER PRIMROSE, C.M.

OF TORONTO, CAN.

COLONEL, C. A. M. C., SURGEON IN CHARGE OF THE MILITARY CLINIC AT THE TORONTO GENERAL HOSPITAL

THE degree of disability resulting from the existence of a defect in the bony vault of the cranium varies within wide limits and is dependent upon a number of factors, including the size of the opening, the amount of scar tissue, and the damage sustained by the meninges of the brain as well as by the brain substance itself. There is also a certain psychic factor which has to be reckoned with in estimating the disability: the mental attitude of the wounded man may tend to give one an exaggerated conception of his trouble as indicated by the subjective symptoms or, in exceptional circumstances, the reverse may be the case.

The series of cases described in the present paper consists of 42 cranioplasties performed in 38 patients. The treatment was carried out in the military wards of the Toronto General Hospital. The writer was in charge of this special clinic and had as members of his staff Lt. Col. Gilmour, Major G. E. Wilson, Major Gaby and Captain Shenstone. Most of the operations were done by these officers.

Age.—The youngest patient operated upon was 19 years of age, the oldest 40 years of age; the average being 26.5 years. It will thus be seen that they were young men, most of them healthy and vigorous, capable of withstanding the immediate effects of an extensive operation satisfactorily and possessing excellent reparative power.

Region of Cranium Affected.—The portion of the skull in which the gap was located is indicated in the following table:

Frontal	12
Frontoparietal	8
Parietal	13
Occipitoparietal	6
Occipital	2
Temporo-occipital	1
Total	42

* Read before the American Surgical Association, June 16, 1919.

The Cause of the Wound.—All the patients received their wounds on active service overseas as follows:

Bullet, shrapnel, etc.	36
Aeroplane bomb	1
Shell concussion causing unconsciousness and fracture due to fall	1
Hit by sandbag	1
Hit by aeroplane propeller	2
Pyæmic abscess and necrosis	1
<hr/> Total	<hr/> 42

Time elapsing between the date of receiving wound and the date of the operation of cranioplasty:

1 case	50 months
1 case	46 months
5 cases	22 to 32 months
11 cases	10 to 16 months
20 cases	4 to 9 months

38 cases, average 13.2 months.

The symptoms complained of by individual patients varied in proportion to the extent of his wound and the region of the brain involved in the injury. Thus where the so-called "silent" areas of the brain were involved the symptoms would be subjective in character only, while in others there would be evidence of an organic lesion, such as hemiplegia, aphasia, defective vision, loss of hearing, loss of smell, etc.

We have made a careful analysis of the symptoms and the results obtained by a successful cranioplasty in the whole series of 42 operations. This seemed to us the best way of estimating from our experiences the benefit, or otherwise, of undertaking an operation for the closure of the cranial gap. The results are as follows:

SYMPTOMS AND RESULTS OF OPERATION

Headache.—Nearly all cases suffered from headache. There were four exceptions.

CASE I.—A man, aged twenty-nine, wounded in the left parietal region in August, 1918, followed by complete hemiplegia (motor and sensory) showed steady improvement after the removal of a F.B. eleven days after the wound was received. He suffered no disability on coming to our clinic save a sense of insecurity: he had no headache and no dizziness: he wished an operation for cosmetic purposes and for safety. A bone graft was done on February 2, 1919, six months after receiving the wound, with excellent results.

CASE II.—A man, aged twenty-six, with a hiatus 2.5 cm. by 2 cm. in

left temporo-occipital region. He had no headache and no dizziness but felt nervous and afraid. He was also subject to occasional fits of unconsciousness when excited or fatigued. There had been right hemiplegia immediately after the wound was received. Some weakness of right arm and leg still remain. A cartilage graft was inserted January 15, 1919, one year after receiving the wound. The result has been entirely satisfactory and he no longer suffers from fits of unconsciousness.

CASE III.—A man, aged twenty-four, with right parietal gap in the skull. A foreign body had perforated his steel helmet and struck a glancing blow on the skull. He became partially hemiplegic, following the wound which was received August 27, 1918. At the time the cranioplasty was performed, January 23, 1919, five months after receiving wound, he had no headache but had some dizziness. A bone graft was inserted and he recovered: he lost his dizziness and secured a sense of safety and security which he lacked before operation.

CASE IV.—A man, aged twenty, received a wound (October 20, 1917) in left parieto-occipital region. He suffered no headache. He had obviously had some degree of hemiplegia after receiving the wound and on admission to our clinic had weakness of the right hand and leg. A gap 7 by 4 cm. was closed by cartilage graft (May 29, 1918). Subsequent to the operation he had a certain amount of headache. The hiatus remained successfully closed. It is worthy of note that all cases free from headache were wounds in the parietal region involving the Rolandic area and suffering hemiplegia.

Results of Operation on Headache.—As a rule headache was completely relieved by a successful cranioplasty. The exceptions were as follows:

CASE I.—A man, aged twenty-four, with a double cranial defect had his first operation for closure of a frontal lesion six months after the wound, and a second operation for closure of an occipital defect two months subsequently. These were successful cartilage grafts. The headaches were only slightly relieved.

CASE II.—A man, aged twenty, with a left parietal lesion had a successful cartilage graft seven months after the wound. The headache was greatly relieved but not entirely.

CASE III.—A man, aged thirty, with a large right frontoparietal lesion had a cartilage graft twenty-four months after wound. The headache persisted.

CASE IV.—A man, aged twenty-two, with a right frontal lesion had a cartilage graft seven months after wound. His headache was, if anything, worse than before.

CASE V.—A man, aged twenty-nine, with a left parietal defect had cartilage graft ten months after wound. The headaches were relieved but not entirely abolished.

CASE VI.—A man, aged twenty-three, with a right parietal defect had cartilage graft twenty-two months after wound. There was no improvement in headaches.

CASE VII.—A man, aged thirty-three, with right parietal defect

ALEXANDER PRIMROSE

had bone graft four months after wound. The headaches persisted as before.

CASE VIII.—A man, aged twenty-seven, with parieto-occipital defect had bone graft seven months after wound. The headaches continued.

CASE IX.—A man, aged twenty, with parieto-occipital defect had cartilage graft seven months after wound. The headache was largely relieved but not wholly.

CASE X.—A man, aged thirty-one, with right parietal defect had cartilage graft twenty-two months after wound. His headaches and dizziness were not relieved.

The question of relief or otherwise from headache was not dependent upon the length of time which elapsed from the time of the wound until the defect was closed. Thus a man suffering constant headache was relieved by a cranioplasty after a lapse of fifty months, while in another case there was no relief of headache after a lapse of four months.

Dizziness.—In most instances if a man had no headache he had no dizziness, but, as a fact, in the whole series of 42 cases there were only four cases free from either headache or dizziness. The dizziness was a very distressing symptom. The conditions under which it developed varied:

Thus one man, aged twenty-two, with a left parietal gap, got dizzy when he went to bed and suffered a very disagreeable sensation as if the bed were upsetting. Another man, aged twenty-three, with a frontal gap 5 cm. by 3.5 cm. would occasionally fall from dizziness but would not lose consciousness. Another man, aged thirty-three, with a posterior parietal gap (4 cm. by 4 cm.) felt dizzy when lying down. On the other hand, a man, aged thirty-two, with a left frontal gap (2.5 cm. by 5 cm.) was compelled to lie down for relief when he got dizzy. Another man, aged twenty, with a parietal gap (5 cm. by 5 cm.) would sometimes fall because of dizziness. This man had worn rubber heels in order to prevent jarring and by this means obtained considerable relief from his headache and giddiness.

The headache and dizziness would be aggravated by exertion or fatigue, and would often be induced by turning the head rapidly.

Results of Operation on Dizziness.—The relief of dizziness by operation was more pronounced than that of headache. The exceptions were few.

CASE I.—A man, aged twenty-four, with a double lesion, one in the parietal and one in the occipital region, had a bone graft in the parietal gap five months after the wound and a cartilage graft in the occipital gap four months subsequently. The attacks of dizziness were much less frequent, but they were not entirely relieved.

CASE II.—A man, aged thirty-one, with a right parietal lesion had a cartilage graft twenty-two months after wound. His dizziness and headache were not relieved.

Loss of Memory.—This was recorded in seven specific instances, but there were doubtless others where the history is incomplete. It was markedly the case that the loss of memory was for recent events, while incidents of older date were comparatively readily recalled. The regions involved were as follows: (1) Fronto-parietal; (2) left parieto-occipital; (3) double = left parietal and left occipital; (4) left parietal; (5) frontal; (6) right frontal; (7) parieto-occipital.

Results of Operation.—The effect of operation was naturally not immediately apparent, but in some instances it was noted after a lapse of some weeks or months the memory was much improved.

Deafness.—Deafness was recorded in four instances. These were gaps recorded as follows: (1) Left frontoparietal; (2) left parietal; (3) left temporo-occipital; (4) left parietal.

The results of operation were not appreciable.

Noises in the Ear.—There were two cases, one a gap in frontoparietal and the other in a similar locality.

The result of operation was not appreciable.

Defective Vision.—There were six cases in which vision was affected.

CASE I.—A man, aged twenty-four, with a double lesion, one gap (5 cm. by 3 cm.) in the frontal, and another gap (3 cm. by 3 cm.) in the occipito-parietal region, complained that vision was blurred.

CASE II.—A man, aged twenty-four, with double lesion, one gap in the left parietal and one in the left occipital region, had homonymous hemianopsia with 75 per cent. disability.

CASE III.—A man, aged thirty-two, with a left parietal lesion complained of "poor vision."

CASE IV.—A man, aged twenty-two, with right frontal lesion complained of vision becoming blurred.

CASE V.—A man, aged thirty-three, with a parieto-occipital lesion had right-sided homonymous hemianopsia.

CASE VI.—A man, aged twenty-five, with left frontal lesion suffered from "eye strain."

The Results of Operation.—No improvement was apparent in any of these cases.

Aphasia.—There were five cases in which aphasia was noted in varying degree:

CASE I.—A man, aged twenty-six, with a left frontoparietal lesion had difficulty in speech and was at first unable to read: he gradually regained the power of reading.

CASE II.—A man, aged twenty-six, with a left anterior parietal lesion had difficulty in speaking.

CASE III.—A man, aged twenty-two, with a right frontal lesion could speak and read as well as formerly, but had some difficulty in recalling names.

CASE IV.—A man, aged twenty-two, with a left parietal lesion had difficulty in putting thoughts into words.

CASE V.—A man, aged thirty-three, with a parieto-occipital lesion had lost at first the power of speech. This gradually improved, but his speech was still slow twenty-nine months after the reception of wound.

Results of Operation.—There were no observations to suggest that the operative procedure had any effect upon the aphasic condition. Many of these cases showed a slow process of recovery before the operation was undertaken and this continued subsequent thereto.

Hemiplegia.—There were 15 cases of hemiplegia in varying degrees. Unfortunately, no accurate clinical record is available of the precise extent or degree of the hemiplegia which supervened after receiving the wound. Our patients on admission to our clinic exhibited such symptoms as exaggerated reflexes, spastic gait, anæsthesiæ, Babinski's sign and certain contractures.

CASE I.—A man, aged twenty, with a left parieto-occipital lesion had weakness of the right hand and leg, which was observed for two months after receiving wound: this had almost entirely cleared up when he came to our clinic seven months after the wound.

CASE II.—A man, aged twenty-four, with double lesion, left parietal and left occipital, had immediate weakness of the right arm and leg: this continued when examined nine months after the wound.

CASE III.—A man, aged twenty-six, with a left parietal lesion had right hemiplegia which cleared up, but weakness still continued thirteen months after the wound.

CASE IV.—A man, aged thirty, with a left occipital lesion had the right leg partially paralyzed.

CASE V.—A man, aged twenty-six, with a left temporo-occipital lesion was trephined the day after being wounded. He was paralyzed in the right arm and the right leg. When coming to our clinic twelve months after being wounded he walked with a limp and had weakness of the right leg. There was also marked weakness of the right hand. Two months after repair of the cranial gap the record states that there was marked improvement in function in the leg and hand.

CASE VI.—A man, aged twenty-six, with a left frontoparietal lesion had a fit immediately after the injury and was paralyzed in the left side. He was unconscious for three weeks, a fortnight later the paralysis cleared up on the left side and the right side became paralyzed. This subsequently cleared up almost entirely, but after a cartilage graft, fifteen months subsequent to the wound, right hemiplegia again developed and he was readmitted after a lapse of six months, suffering also from severe Jacksonian epilepsy. The graft was removed and a fascial graft substituted after free dissection of the scar tissue. The paralysis completely cleared in ten days and the fits ceased to recur.

CASE VII.—A man, aged thirty-one, with a right parietal lesion had complete left hemiplegia which cleared up largely, so that twenty-two

months after the wound a weakness of left arm and leg is alone recorded.

CASE VIII.—A man, aged twenty-four, with a right parietal lesion was partially paralyzed on the left side and lost complete control of the left hand: this had completely cleared up when examined five months after the wound.

CASE IX.—A man, aged twenty-nine, with a left parietal lesion had a foreign body removed in the C.C.S. and is recorded as having the entire left side paralyzed. He developed Jacksonian epilepsy while the hemiplegia largely cleared up. Such was his condition when he entered our clinic ten months after receiving wound.

CASE X.—A man, aged thirty-three, with a right parietal lesion was paralyzed in the left arm and leg for a month. There was still weakness in the arm and leg when examined four months after wound.

CASE XI.—A man, aged thirty-five, with left parietal lesion had hemiplegia and twenty-eight months after the wound he walks with a spastic gait.

CASE XII.—A man, aged twenty, with a left parieto-occipital lesion had weakness of the hand and leg for two months after the wound, when it cleared up.

CASE XIII.—A man, aged twenty-seven, with a right frontoparietal lesion had weakness of the left arm and leg when examined eighteen months after the wound.

CASE XIV.—A man, aged thirty-three, with a left parieto-occipital lesion of a most extensive character (gap 9 cm. by 12 cm.) had immediate right hemiplegia which gradually improved. When examined thirty-two months after the wound there remained only a weakness and slight numbness of the left foot.

CASE XV.—A man, aged thirty-five, with a right occipital lesion had a left hemiplegia which gradually improved. When examined thirty-two months after the wound there remained only a weakness and slight numbness of the left foot.

Lesions Producing Hemiplegia.—Parietal, 7; parieto-occipital, 3; frontoparietal, 2; temporo-occipital, 1; occipital, 2; total, 15.

Results of Operation.—It is difficult to secure sufficient data in detail from the previous records of these men to make a comparative study as valuable as otherwise would have been the case. Nevertheless, some instructive observations were made, although in the most general terms, and with a most meagre history of the progress of certain of these cases.

It would appear that the hemiplegia was more or less complete in many instances and developed either immediately on receipt of the wound or, what was more commonly the case, within the first few hours afterwards. In every instance the condition showed progressive improvement, usually leaving a residual weakness, but in exceptional cases clearing up entirely.

It cannot be said that the closure of the defect had any remedial effect upon paralysis in these cases. In one instance hemiplegia developed after a cartilage graft had been inserted, along with Jacksonian seizures. The paralysis entirely cleared up and the fits ceased to recur after removal of

the graft, free dissection of scar tissue and the insertion of a fascial graft.

Jacksonian Epilepsy.—There were seven cases in whom epilepsy developed. Six of these were of the Jacksonian type.

CASE I.—A man, aged twenty-four, with a double lesion, one in the right frontal region and one in the occipitoparietal region. He was admitted to the clinic six months after the wound and had two fits in the ward before operation. The day after the operation for closure of a gap he had a fit, but they did not recur.

CASE II.—A man, aged twenty-six, with a left frontoparietal lesion had a fit immediately after being wounded. On admission fifteen months after the wound he was having frequent fits, as many as three a day. After operation he had three fits during the first night. During the subsequent fifty-four days while in hospital he only had one fit. These, however, subsequently recurred and after a period of four months he was readmitted; the cartilage graft was removed and a fascial graft substituted after free dissection of scar tissue, including dura mater and cortex. At the time of his readmission he had right hemiplegia. After the last operation this completely cleared in ten days and no more fits developed up to time of discharge nineteen days subsequently.

CASE III.—A man, aged twenty-nine, with a left parietal lesion, wounded November, 1917. A F.B. was removed in the C.C.S.; paralysis of the entire left side followed. This cleared up and the first fit occurred three months afterwards. Fits recurred about once a month. There was an aura of choking and nausea. When the fit develops it begins on the right side, clonic in type, he becomes unconscious and cyanosed, sleeps for two hours and awakens with terrific headache. Cranioplasty September 25, 1918, and reported on return of Jacksonian epilepsy in five months (February, 1919).

CASE IV.—A man, aged twenty-six, with a left parietal lesion, wounded August 15, 1917, followed by right hemiplegia at the C.C.S. Bits of bone and brain matter were removed. Seventeen days afterwards part of a hernia cerebri were removed, and four days subsequently the entire hernia cerebri was removed. He had aphasia, blurred vision, dizziness and frontal headache. The fits were Jacksonian in type, beginning by clonic spasms of right foot. Cranioplasty September 23, 1918, (cartilage) was performed. The wound suppurated and the cartilage sloughed out. Transferred to C.M.C.H. November 27, 1918. One fit had developed the day after operation. He had respite from these seizures for a time, but they eventually recurred and he died in a convulsion four months after the operation.

CASE V.—A man, aged twenty-six, with left temporo-occipital lesion. He was trephined the day after being wounded. He was paralyzed in the right arm and right leg. There is no history of convulsions following, but he suffered from occasional attacks of unconsciousness when excited or fatigued—*petit mal*—a cranioplasty was done January 15, 1919; one attack occurred the day after the operation but none subsequently.

CASE VI.—A man, aged thirty-three, with a very extensive gap in parieto-occipital region. Right hemiplegia followed the wound and subsequently he developed fits which recurred at the rate of about one every three months. A bone graft from the cadaver was introduced twenty-nine months after the wound. He had a fit three days afterwards and a second seizure three and a half months subsequently.

CASE VII.—A man, aged twenty-seven, with a right frontoparietal lesion was paralyzed in the left side. This largely cleared and he had a bone graft inserted, about a year after receiving wound, in Washington. Subsequently he developed Jacksonian epilepsy, with recurrence of the paralysis, and two years after the wound the bone graft was removed, a free dissection of scar tissue made, and a fascial graft substituted. He made an excellent recovery: the paralysis entirely disappeared and thus far (four months after operation) the fits have not recurred.

Lesions Associated with the Development of Epilepsy.—Frontoparietal, 2; frontal and occipitoparietal, 1; parietal, 2; parieto-occipital, 1; temporo-occipital, 1; total, 7.

Results of Operation.—It is worthy of note that of the cases in whom Jacksonian epilepsy developed all had a history of hemiplegia with one exception, and in all the gap existed in the parietal region of the cranium.

It is hazardous to draw any conclusions as to the effect of closure of a cranial gap upon the course of epilepsy. Undoubtedly relief is in many instances attained, but one cannot say that a permanent cure is effected. In civil practice one has seen acute epilepsy of the Jacksonian type clear up entirely after operation for cerebral abscess, and the patient continue free from seizures for years (in one case followed for nine years) with apparently a permanent cure. On the other hand, in my records I have the history of a man who developed his first attack twenty years after a brain injury. It is, therefore, impossible to say that we have effected a cure when, after a cranioplasty, our patients, as in some instances, have remained free from attacks for a few months.

Loss of Sense of Smell.—A man, aged twenty-four, had a double frontal lesion. The bullet entered just above the supra-orbital ridge on one side and made its exit above the supra-orbital ridge on the opposite side. There were two gaps with a bridge of bone between. This man had complete loss of smell, due, no doubt, to injury of the olfactory lobe of the brain.

Result of Operation.—The operation had no appreciable effect in restoring function.

Dyspnœa.—One case is recorded as having difficulty in breathing: this was a man, aged twenty-six, with a left frontoparietal lesion who had left hemiplegia and early developed Jacksonian epilepsy. The fits continued and were a feature of his case fifteen months after reception of the wound.

Sense of Fear: Nervous and Afraid of Being Struck on Head: a Feeling of Insecurity.—Such sensations were very common in men who had a gap in the cranium. Illustrated by the following:

CASE I.—A man, aged twenty-six, with a gap (3 cm. by 2 cm.) felt nervous and afraid. These sensations disappeared after cranioplasty.

CASE II.—A man, aged twenty-one, with a left posterior parietal lesion had constant fear of being struck on the head. This was relieved by cranioplasty.

CASE III.—A man, aged twenty-two, with a right frontal lesion was unable to stand any noise without getting extremely nervous.

Result of Operation.—Closure of the gap in such cases is most effective in allaying such distressing symptoms.

Marked Mental Depression.—This was recorded in certain instances. A man, aged twenty-three, with frontal lesion and gap (5 cm. by 3 cm.) who was a great sufferer from headaches and dizziness showed marked mental depression.

Result of Operation.—The result of operation is most beneficial.

Features of the Gap: Size, Pulsation, Impulse on Coughing, Depression Below Surrounding Surface.—The size varied from a small opening 3 cm. in diameter to a very large hole, which in one case measured 12 cm. long and 9 cm. wide. Most of the cases showed pulsation, but where the gap was small and the scar tissue over it firm, pulsation was absent. In nearly all cases there was an impulse on coughing. A very characteristic feature of these cases which was observed in practically all instances was that the soft tissues covering the hole would bulge when the man stooped over with his head between his knees: on assuming the erect attitude the bulging would be replaced by a marked depression. Lying on the operating table with the head slightly elevated and while under the anæsthetic there would be a slight depression as a rule. In one instance there was a marked depression at operation. This was due to the very large size of the gap and to the loss of substance in the meninges and in the brain itself.

Results of Operation.—These unfortunate patients all experienced the greatest possible relief as the result of firm closure of the gap.

The Scar.—The character of the scar tissue varied within wide limits. It became most important to study the degree of scar development and its relation to the gap. One feature common to all was the dense adhesion of the scar to the dura mater, necessitating the most careful dissection of the one from the other. An attempt was made to remove the scar tissue as completely as possible. If this were not done, it would probably slough subsequently, as its vascularity is so poor. Removal of the scar tissue is considered by us a most important feature of our technic.

Nausea and Vomiting.—It is a fact worth recording that in not a single instance was vomiting recorded as a symptom. This symptom is common in pathological lesions within the cranium, such as tumors, inflammatory conditions, etc., where increased pressure effects are a feature of the case. It is, therefore, perhaps not surprising that in the cases under consideration, where the intracranial pressure is, if anything, diminished, vomiting does not occur.

In one case there was nausea, this was present in a man aged thirty-two, who was knocked over by a shell exploding near him, sustaining a fracture of the skull in the left parietal region as the result of his fall. Four months after the injury nausea is noted as a feature of his case with headache and dizziness. Cranioplasty was performed, and all his symptoms were relieved.

Restricted Movement of the Lower Jaw.—A man, aged twenty-eight, with a right frontoparietal lesion situated immediately above the zygoma, the scar tissue was firmly incorporated with the temporal muscle, resulting in a fixation of the jaw so that the movement at the temporo-maxillary joint was restricted and he was unable to open his mouth except to a very limited extent. The muscle was freed at an operation performed in our clinic two years after receiving the wound, as a result the jaw movement was increased by 10 per cent.

Result of Operation.—The result of operation here, by the removal of scar tissue, was effective in restoring function to a considerable degree.

Type of Graft.—The type of graft was as follows: Cartilage, 27 cases; bone, 13 cases; fascia, 2 cases; total, 42 cases.

The cartilage grafts were all autogenous: the cartilage was removed from the lower costal cartilages of the patient.

The bone grafts were also autogenous with one exception, and were removed from the tibia of the patient. The exception was that of a large cranial defect which was closed by a piece of parietal bone removed from the human cadaver.

The fascia used was the fascia lata from the thigh of the patient.

There were three cases in which a silver plate had been inserted in England to close the gap. In each instance the plate had to be removed. These were as follows:

CASE I.—A man, aged twenty-two, wounded in November, 1917, in frontoparietal region had a silver plate inserted to close the gap. The wound became infected and the plate was removed six months after its insertion. After another lapse of six months, the wound being soundly healed, the writer made a successful cartilage graft relieving the man of his headache and dizziness.

CASE II.—A man, aged thirty, wounded in November, 1914, in the occipital region had a silver plate inserted in England four months later. The history states that following a fit of unconsciousness he had the plate removed in June, 1915. There was evidently some infection as a sinus persisted when admitted to our clinic. In spite of this, however, Major Wilson succeeded in doing a successful cartilage graft in January, 1919.

CASE III.—A man, aged twenty-two, was wounded in October, 1917, in the frontal region. A month afterwards he had a silver plate inserted. The wound became infected and the plate was removed six months later. The wound then healed. In October, 1918, Captain

Shenstone performed a successful cartilage graft followed by complete relief of his headache and dizziness.

In one instance a bone graft which had been inserted in Washington was removed in our clinic.

The case is as follows:

A man, aged twenty-seven, was wounded in 1917 and had two operations in France at both of which fragments of bone were removed. Later a bone graft was done in Washington. He came to us because of having developed severe convulsive seizures and an incomplete hemiplegia with weakness of the leg and arm. In January, 1919, Major Wilson removed the bone graft, and made a free dissection of the scar tissue along with a considerable piece of dura mater. He replaced this by a fascial graft and its adherent fat. The fat was turned towards the brain cortex. The wound healed and the paralysis completely disappeared; thus far the convulsions have not recurred.

The Technic of the Operation.—The method of operating in this clinic has recently been described by one of our staff, Major Wilson, in the ANNALS OF SURGERY for March, 1919. The principles involved and the objects aimed at may be summarized as follows:

In exposing the gap in the cranium, the flap of scalp which is turned down must be freed as far as possible from all scar tissue. This is essential for two reasons, first to get rid of all tissue which may harbor infection and secondly to provide a covering for our graft which has a good blood supply. The flap does not include the pericranium which is left for the moment undisturbed. The area of skull uncovered must leave a margin of at least 3 cm. surrounding the gap. The reflection of the flap is not easy immediately over the gap, because at this point one usually encounters scar tissue, and it is firmly adherent to the dura mater, which is also scarred. In dissecting the flap free from the dura the latter is often opened at points from which cerebrospinal fluid escapes. Occasionally a fine catgut stitch is necessary to close these small wounds of the dura. In some instances it has been necessary to sacrifice a considerable piece of the dura mater. Under such circumstances we have found it quite satisfactory to transfer a piece of fascia lata from the thigh. The patch of fascia is placed with its fatty side towards the brain cortex, and with its margins underlying the edges of the dural gap. It is then secured in place by a few fine catgut sutures. The pericranium is now cut by a vertical incision which encircles the gap in the bone. This cut is made .5 cm. from the bony margin of the gap. The ribbon of pericranium thus mapped out is raised from the bone by an elevator and turned in upon the dura mater. One continues the separation in the same plane and separates the dura from the under aspect of the bone. By this means the bony margin of the gap is entirely bared on both surfaces. If any rough irregularities of bone project from the margin these are removed by rongeur forceps. The pericranium surrounding the field of opera-

tion is also separated from the bone by an elevator to the depth of 1 cm. The object of this is to utilize the cut margin of the pericranium for the purpose of securing the graft, when in place, by suture. By means of a burr or gouge the bony margin is now bevelled off, removing the outer table and leaving the inner table to act as a shelf to receive and support the graft. The bed is now prepared for the reception of the graft. Throughout the operation most careful attention is paid to hæmostasis. If it is proposed to make a cartilage graft, then a vertical incision six inches long is made two inches to the right of the middle line over the lower costal margin. The incision is carried down through the rectus muscle, which is retracted, and the cartilages bared. One then removes two-thirds of the outer surface of the cartilage, shaping a graft of sufficient size to fit the gap in the cranium. The piece of cartilage is subsequently fashioned to the exact shape and size necessary by cutting it with a sharp knife upon a wooden block. It is now placed in position, the edges of the graft resting firmly upon the ledge of the inner table, which has been prepared for its reception. Fine catgut sutures are now passed through the cartilage and the loose margin of pericranium which immediately surrounds it. The flap of scalp is then replaced over the graft and accurately secured by the silkworm-gut suture. A small drain being inserted at a suitable point to prevent the formation of a hæmatoma. This drain is retained in position for twenty-four hours.

The Cartilage Graft.—In placing the cartilage graft one or two additional precautions are necessary. The cartilage must be laid with the perichondrium towards the dura. In fact, it will be found difficult to place it otherwise, as it naturally curls somewhat to form a slightly concave surface on the side of the perichondrium, thus fitting more readily the contour of the skull. We have learned by experience that it is absolutely necessary to make the graft completely bridge the gap and lie supported upon the ledge of inner table prepared for its reception. If, for example, two pieces of cartilage are used to span the gap and their ends meet and lie free in the centre of the gap, the result is a failure to secure firmness, a certain amount of yielding will occur in such a graft which will permit of impulse on coughing and possibly pulsation. On the other hand, if the gap is unusually large, it may be necessary to use several pieces of cartilage to fill it. A good firm result may be obtained under such circumstances, provided each piece of cartilage completely spans the gap and rests securely at either end upon the ledge of inner table.

The Bone Graft.—The bone graft in all our cases, with one exception, has been cut from the tibia by means of a saw. Before doing this, however, the periosteum is cut through over an area of somewhat larger pattern and turned in over the graft while the saw cut is being made. The graft is now raised from the tibia by means of a chisel. The graft is placed in position in the cranial gap and is fitted in similar fashion to that described for the

cartilage graft. The redundant periosteum is now sutured to the surrounding pericranium and the graft is thus securely retained in place. In some instances we have drilled the graft and similarly drilled holes in the ledge of inner table and secured the graft by passing catgut through these holes, but this is not necessary.

The Bone Button Graft.—One of our staff, Major Gaby, has devised a method of making bone grafts, which, in suitable cases, answers admirably. The gap in the cranium is exposed in the manner already described. A trephine is then applied over the gap and the outer table cut through. The outer table within the circle of the trephine cut is then chiselled off and the inner table left as the shelf for the reception of the graft. The same trephine is now used to cut a graft from the tibia, cutting the periosteum over an area embraced by a larger circle and turning it in over the graft before the trephine is applied. A button of bone of suitable size is now isolated by the trephine and separated from the bone by means of a fine chisel. This is now placed in position in the cranial gap and secured there by stitching the periosteum to the pericranium with catgut. The method answers admirably, provided the gap to be closed is more or less circular in shape and not too large. Major Gaby has succeeded in closing the gap requiring a trephine two inches in diameter, by this means utilizing the entire width of the inner surface of the tibia. The tibial surface is not quite wide enough for the two-inch trephine, but the small part of the graft at opposite sides which fails to reach the supporting ledge in the cranial gap does not materially interfere with the firmness of the result. In small gaps the button fits accurately and is supported around its entire circumference.

The same principle may be applied in certain cases where the long diameter of the defect is too great for the use of a trephine. A rectangular ledge is cut by an Albee motor saw with a guide which prevents the saw cutting to a greater depth than the diploe. The outer table is then chiselled off, as in the trephine method. A tibial graft of accurate size is then cut with the motor saw, cutting to the same depth. The graft is then freed from the tibia by a very thin osteotome. This graft is then fitted in place in the same way as the bone button.

The Bone Graft from the Cadaver.—This means of closing a gap was utilized in one of our cases. It is one of unusual interest because of the very large size of the gap accompanied by a considerable loss of cranial contents. The method adopted will best be understood by detailing the case *in extenso*. It is as follows:

A man, aged thirty-three, with a parieto-occipital lesion, the result of a wound received in September, 1916, was operated upon in our clinic twenty-nine months afterwards. He had hemiplegia after the wound and developed Jacksonian epilepsy. On admission he walked with a spastic gait, had flexure of the hand with plantar flexion of the

foot and right homonymous hemianopsia. His fits recurred at intervals of about three months. He had a very large cranial defect.

A piece of the parietal bone of a cadaver was prepared for the purpose of the graft. The exact measurements were 12 cm. by 9 cm. The intention was to close the gap in the cranium of our patient by placing the graft in the hiatus after preparing it in a special manner to ensure its vascularization and its firm consolidation with the tissues. The study of the fate of the graft in cases where it has been used in the plastic surgery of bone has led to considerable discussion as to the preservation of vitality in the case of the transference of the graft direct from living bone. Whatever interpretation may be placed upon the histological findings in experimental work there is no room for doubt as to the nature of these findings. Gallie and Robertson have shown that in the transplantation of grafts in the long bones of dogs there is a certain definite histological picture observed, while studying the changes which take place in the graft at various intervals until complete union of a fracture has occurred and firm consolidation of the graft with the living bone of the recipient dog has been secured. There is no difference in their findings between dead (boiled) bone and bone which has been immediately transferred from living bone for the purpose of the graft. The main features are vascularization of the graft by the ingrowth of new blood-vessels and the deposition of cells (osteoblasts) leading eventually to firm union. It would seem, therefore, that the graft should be prepared in such fashion as to favor this vascularization as much as possible. Hence it is found that cancellous bone is more suitable for the purpose than compact bone. The more porous the graft the more readily the blood-vessels grow into it. The sclerosed bone in the neighborhood of most ununited fractures is very unsuitable for such vascularization.

With these objects in view, it was determined to prepare the large graft of parietal bone so as to favor its vascularization as much as possible. The inner table of the piece of parietal bone removed from the cadaver was reamed off, leaving the rough cancellous surface of the diploë exposed. The bone was then penetrated by numerous holes through its entire thickness, these holes were 3 mm. in diameter and were placed with intervals of about 6 mm. over the entire graft, thus converting it into a sieve while still preserving a firm structure of sufficient stability for our purpose. The graft was then boiled and was preserved aseptic. At the operation the scalp of the patient was turned down in a flap, after a curved incision, so as to expose the hiatus in the skull, separating by dissection the scalp from the underlying adherent dura mater. This dissection was rendered difficult by the scar tissue present and some holes were made in the dura, allowing escape of cerebrospinal fluid during the process. Eventually the dissection was successfully accomplished and the margins of the hiatus were clearly defined. The pericranium was put 1 cm. from the edge of the hiatus and was detached from the bone and turned in upon the dura mater, the latter was separated for 1 cm. from the under aspect of the bone

edge all around the hiatus, so that one had the entire irregular edge of the bone surrounding the gap completely bare. The outer table of this bony ledge was reamed off: the margins of the graft had previously been bevelled in similar fashion, but on its inner surface; the graft was cut so that it fitted the hiatus accurately. The ledge formed of the inner table of the patient's skull was drilled with a number of holes and the graft was firmly secured in place by catgut passed through these holes and through the adjacent holes in the graft.

When we placed the graft in position over the hiatus it became evident that through loss of brain substance there was a considerable depression so that a considerable space existed between the graft and the dura mater underlying it. It was recognized that this would be a distinct menace, as it would certainly fill with blood or serum which would favor suppuration. We therefore filled in this cavity by removing a flap of fascia lata from the man's thigh. Fortunately he was fairly stout and we took a good thick pad of superficial fat along with the fascia lata. The plug of fat was turned towards the dura and the flap of fascia secured in place by a few catgut stitches, thus successfully filling the space beneath our bone graft. The scalp wound was then brought over the graft and secured by interrupted silkworm-gut sutures.

The man made an excellent recovery. It is now four months since the operation. He had a fit three days after the operation and a second seizure after the lapse of three months and a half. He is infinitely more comfortable than before the operation; he can now walk without assistance, a thing impossible for him hitherto. He has lost the headache which formerly distressed him: the mental depression from which he formerly suffered has entirely disappeared. The X-ray picture four months after the graft was inserted shows marked changes with gradual disappearance of the holes in certain portions of the graft, with apparently some condensation of the bone at these points.

The Fascial Graft.—The value of this form of graft is apparent in certain cases. In particular where there is much scar tissue and a graft of bone or cartilage is not successful. The operation consists in making a very free dissection of the scar tissue, including the implicated portion of the dura and cutting well down upon the cerebral cortex. This usually means, in such cases, the removal of a piece of dura almost as large as the cranial defect. A suitable piece of fascia lata is now obtained along with some of the overlying fat. The patch of fascia is somewhat larger than the defect in the dura. It is placed in position with the fatty surface towards the brain. The edges of the graft are made to underlie the edges of the dura and are secured there by fine catgut sutures. The scalp flap is then brought over the graft and sutured in position. Major Wilson of our clinic carried out this procedure in two cases with excellent results. In one case a man, aged twenty-six, had an aggravation of epileptiform seizures after a cartilage graft and became hemiplegic. The cartilage graft was removed after the

lapse of a month and the fascial graft substituted. The paralysis promptly cleared up and the fits ceased to recur. The case is too recent to conclude that he has permanent immunity from fits. The other case was a man, aged twenty-seven, wounded in 1917 in the frontopareital region. A bone graft was subsequently introduced, and after a lapse of some months he was admitted to our clinic suffering from severe convulsions requiring an anæsthetic to control them and with left hemiplegia. The bone graft was removed and a fascial graft introduced. The paralysis subsequently disappeared and he had no recurrence of fits when last heard from three months after operation.

Mortality.—There was no mortality in the series of 42 operations. Some of the patients in whom extensive operations were performed suffered severely from shock, but they all recovered. One of our patients (No. 4 in the series of cases of Jacksonian epilepsy) left the clinic, but subsequently continued to have convulsions of a most aggravated type. He eventually died in a convulsion four months after his operation. He had been subject to these seizures for six months prior to the performance of the cranioplasty, consequently his death could not be ascribed to the operation.

Infection.—It is remarkable that infection does not occur more frequently in view of the amount of scar tissue present and the fact that the vast majority of these patients must have had infected wounds primarily. In two of our cases a granular material, resembling bone dust, was found at the margins of the gap in the cranium. A culture of staphylococcus was obtained from both of these. In spite of that fact both wounds healed without suppuration and a firm successful closure was secured. It is obvious that the resistance of the tissues of the scalp and cranium to infection is much greater than the tissues about an infected bone in the extremities, where, notoriously, plastic work invariably fails in the presence of infection.

Infection of the wound followed in five of our cases only. In two of these cases (which were cartilage grafts) in spite of the infection, the wound healed and the graft remained firm. In three of the cases the graft was either removed or sloughed out. Two of these were cartilage and one was a bone graft.

Causes of Failure of the Graft.—I refer here merely to the failure to secure a firm closure of the gap by our operation. There were five of these. Three of them were the three cases of infection referred to in the preceding paragraph where the graft came away. The other two were among our first cases in which we failed to make the cartilage completely span the gap and lie as they should have done with each extremity supported on the ledge of inner table prepared for it. In one of these we removed the first graft and performed a second operation which was completely successful. The other showed some pulsation and impulse on coughing, but it was so slight we did not interfere. His symptoms were improved, but he still suffered from some slight headache.

The Fate of the Graft.—Our cases are all too recent to make any final statement regarding this most important phase of the subject under discussion. We have, however, made one or two observations of interest. Thus, in removing the cartilage in the case of insecure graft referred to above, one found it firmly united to the tissues in which it was imbedded, including the margins of the gap. Our pathologist, Capt. Laughlin, reports the histological findings as follows:

The section embraces a portion of cartilage and subjacent fibrous tissue stroma. Fibrous tissue is firmly bound to cartilage over all its surface. In three or four places there are small collections of fibroblastic cells, lying in the cartilaginous stroma, which appear to be pushing inwards from the surrounding fibrous tissue. New blood-vessels accompany the growth or invasion of the cartilage. The cartilage consists of chondroblastic cells, in a more or less hyaline matrix, but scattered throughout are deeper staining areas. (Irregular deposits of calcareous material.) The cartilage is normal in appearance except for the fibrous tissue changes in the surface areas. The surrounding tissues are composed of a fibrous tissue stroma and new blood-vessels, with scattered areas of round-celled infiltration.

This piece of cartilage had remained *in situ* for eight months. The wound had healed without infection. We learned at least from this case that there had been no tendency to atrophy, and the cartilage had become firmly united to the margins of the gap. There is a suggestion that some calcareous deposit had occurred, but this, obviously, if it did occur, was extremely meagre and insignificant.

We have as yet little evidence regarding the fate of the bone graft. That changes occur in the bone is brought out in a striking manner in the X-ray picture taken of the very large graft, made from the cadaver (Figs. 2 and 3). The graft was 9 cm. by 12 cm., was composed of the outer table of the skull and was perforated by many holes 3 mm. in diameter. Under the X-ray the sieve-like appearance of the graft is evident. An X-ray plate taken three and a half months after the graft was inserted shows a gradual disappearance of the holes with apparently some condensation of the tissues in the places where the holes are disappearing. On feeling this man's head the graft is perfectly firm and solid as far as the graft is concerned. This fact, taken with the appearance in the X-ray plate, would lead one to hope that the changes which are obviously going on in the graft are such that it will remain and serve to close the hole permanently and successfully.

We have in no instance seen any tendency to absorption of the graft. Judging from experimental evidence and from our own experience we are hopeful that either bone or cartilage, if successfully implanted as a graft in a cranial defect and if the wound heals without sepsis, will unite with the tissues in which it is embedded and will persist as a permanent and satisfactory closure of the gap.

The Relief of Symptoms by Cranioplasty.—We have already studied the

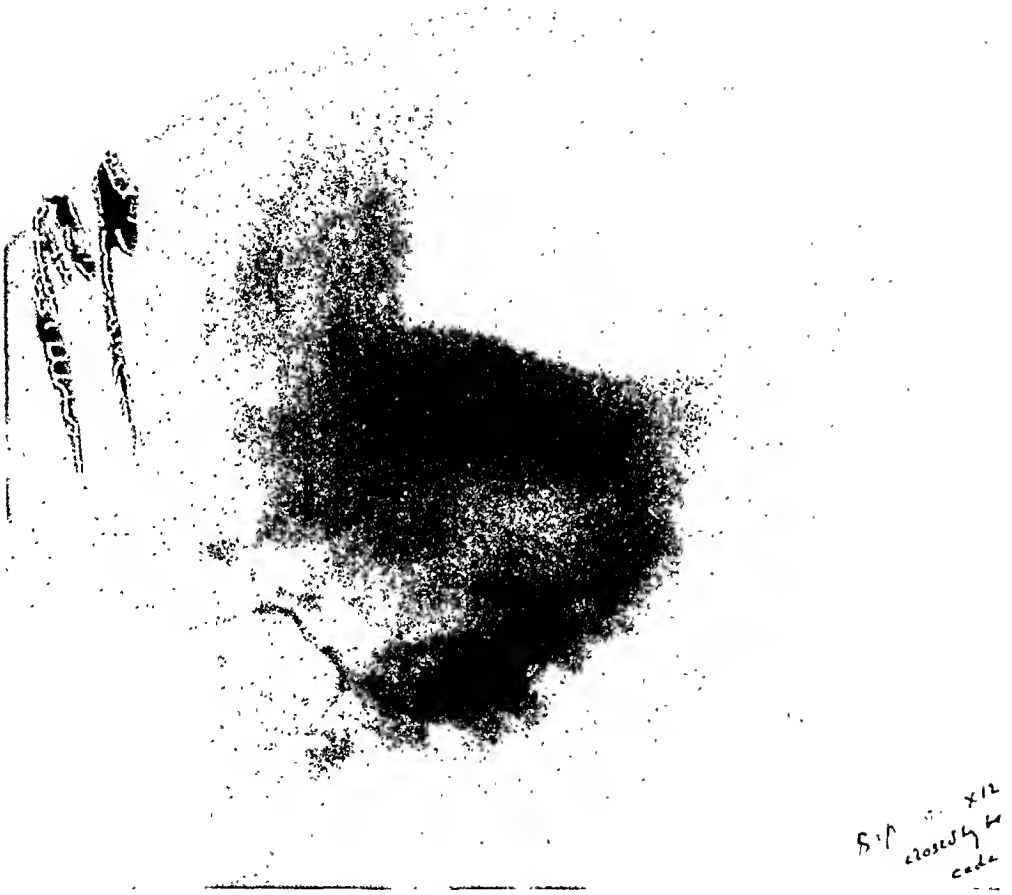


FIG. 1.—Gap 9 cm. by 12 cm. closed by bone from a cadaver. X-ray before operation.

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relief of individual symptoms in our series. We may now make a general statement as follows: For our purpose we shall only consider the cases in which a completely satisfactory closure of the gap has been accomplished by a firm graft. There were 34 cases in which the operation *per se* was thus completely satisfactory. The bone graft under such circumstances and the cartilage graft seemed equally efficient.

Cases completely relieved of distressing symptoms.....	19
Cases rendered worse by the operation	2
Cases improved but not wholly relieved.....	8
Cases with no change in the symptoms	5
Total	34

CONCLUSIONS

It is possible to successfully close a gap in the skull by a graft of bone or cartilage, and thus restore the integrity of the unyielding cranial vault. The operation is attended by little danger to life as shown by the absence of mortality in our series of cases. The relief of symptoms directly dependent upon the existence of the gap is, as a rule, immediate and complete; such as headache, dizziness, the fear of injury and the sense of insecurity, occasionally the worry and mental depression dependent upon the possession of an ugly deformity particularly in the forehead. It is probable that when such a symptom as headache is not relieved, the trouble is dependent upon some condition additional to that of the cranial defect. The gratitude expressed by men who are relieved of these comparatively simple but most distressing maladies and who are rid of their deformity is sufficient guarantee that the operation is warranted.

The value of the operation in more complicated cases more particularly those suffering from Jacksonian epilepsy is less evident. Relief has been obtained in some of our cases, as we have noted above, but we can make no useful statement as to the probable permanence of that relief. On the principle that we should remove all sources of cortical irritation, if possible, in such patients, one might argue in favor of the operation, but the graft itself may be a source of irritation as evidenced in the case of one patient already referred to. In this instance a bone graft was removed and a fascial graft substituted with relief from the convulsions up to the present time four months after the operation. In the majority of our cases of Jacksonian epilepsy some measure of relief was undoubtedly secured. This would be explained by the relief of symptoms directly dependent upon the existence of the gap and the presence of scar tissue causing cortical irritation. We believe, therefore, the gap should be closed in these cases in order to eliminate the symptoms due to the existence of the defect and with the hope that in addition the epileptic seizures may be ameliorated.

The effect of operation on such symptoms as defective vision, aphasia,

loss of memory, deafness and other symptoms dependent upon organic cerebral lesions is of little or no value.

The value of the fascial graft is well worth considering. Where there is a cortical irritation, with much scar tissue implicating the dura mater, it is most serviceable to make a free dissection of the cicatricial tissue, removing the patch of dura mater involved and substituting a patch of fascia lata to close the rent. Our cases recorded above demonstrate its usefulness.

Finally, we may conclude by stating our belief that where a gap exists in the cranium it should be closed. The symptoms caused by the existence of the gap and directly dependent upon it will almost certainly be relieved by a successful cranioplasty.

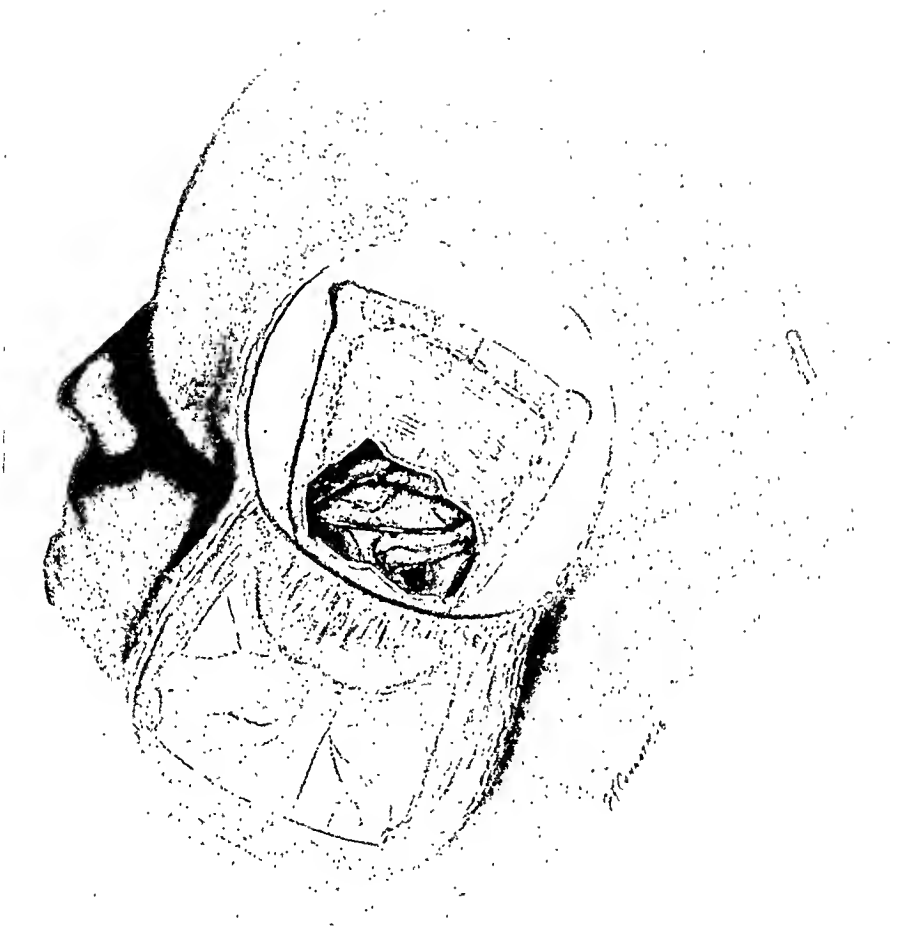


FIG. 1.—Decompression combined with osteoplastic flap. This procedure interferes with the tourniquet.

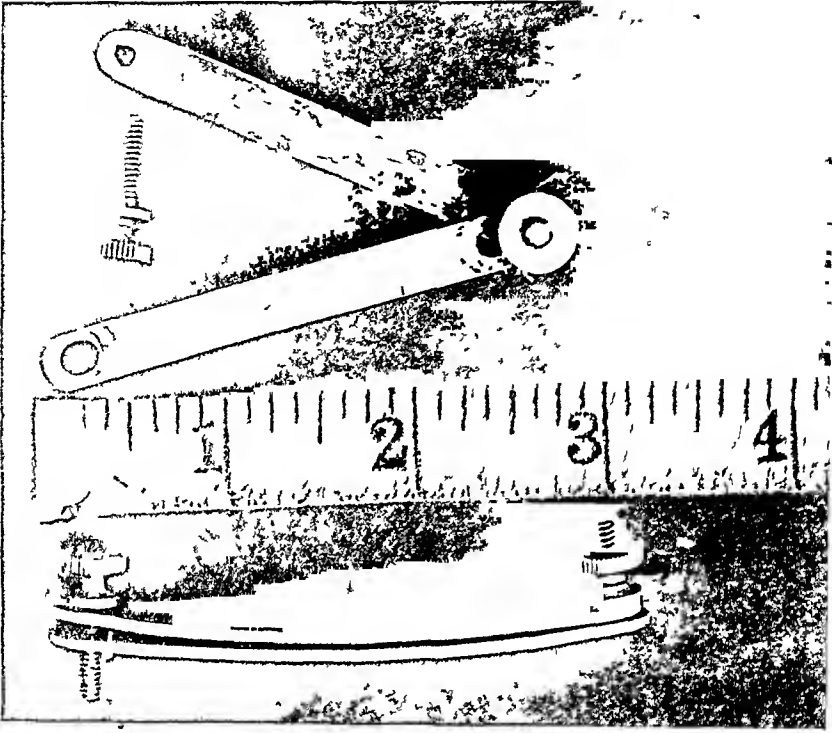


FIG 2 —Shows clamp open and closed

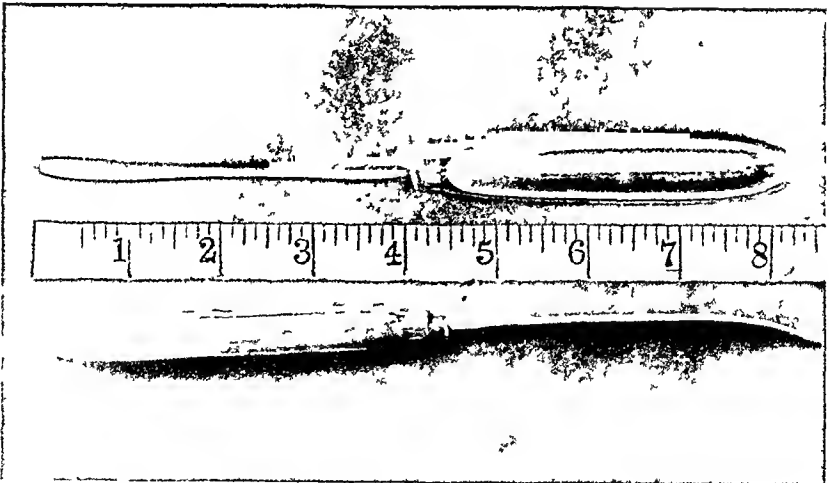


FIG 3 —Staphylopharyngotomy dissector



FIG. 4.—Shows the clamp in place.

A CLAMP FOR OSTEOPLASTIC CRANIOTOMY

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FORTUNATELY, the cranial surgeon no longer is confronted by the problem of controlling hemorrhage from the scalp during extensive craniotomies. Until ten years ago this was an ever-present danger, to combat which specially constructed clamps and various methods of passing sutures were devised by Heidenhain and others. These were all discarded when the tourniquet was introduced for this purpose. The method of applying it was best described by Cushing in "Keen's Surgery," vol. iii, page 263.

I had been making use of this method until four or five years ago. At that time, however, I began to combine more and more frequently a decompression operation with my osteoplastic procedure as shown in Fig. 1. The removal of bone under the temporal muscle released the tension of the tourniquet and troublesome bleeding from both edges of the incision occurred. As I frequently am unable to tell beforehand when I may combine a decompression with my osteoplastic procedure, I discarded the tourniquet four or five years ago and simply clamped all my vessels as I made my incision. This has two objections, first, somewhat more time is consumed in the operative procedure, which is of comparatively little significance if thereby meticulous hæmostasis is obtained. Second, the large number of clamps on both sides of the incision get tangled up and the stripping of the soft tissue from the bone flap may more readily occur, an accident that I always dread, though it has thus far never happened to me.

For these reasons, therefore, I have been making use of the clamp illustrated in Fig. 2, which enables one to dispense entirely with all clamps on the flap side of the incision. It is applied as follows:

The incision is outlined on the skin in the usual way and the field then draped. Two small incisions, each not more than one-half inch in length, are made at the two ends of the incision. These are carried down to the bone. A staphylorrhaphy dissector, Fig. 3, is passed from one incision to the other, stripping the periosteum from the bone. One jaw of the clamp is slipped through this space, the other jaw is slipped into place, and the screws are tightened sufficiently to control all hemorrhage (Fig. 4). They should not be made too tight lest they strangulate the tissues. The clamps are made of varying lengths and shapes to fit different heads.

I have found this a helpful adjunct in my work and trust it may prove of value to others.

THE RESULTS OF SPLENECTOMY IN THE ANÆMIAS *

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SPLENECTOMY as a curative agent has been given a fair trial in three types of the anæmias, and its successes and failures may be reasonably shown by the data at hand. It is my purpose to discuss the operation in cases of splenic anæmia, pernicious anæmia, and hæmolytic icterus from this standpoint.

SPLENIC ANÆMIA

While splenic anæmia is, as pointed out by Osler, a clinical entity, it cannot be said to have a definite pathologic existence. It may be defined as a splenomegalia with a secondary type of anæmia which is progressive but not constant until the later stages. This secondary anæmia has no special characteristics except that as a rule it is accompanied by a leucopænia, although we have seen otherwise typical cases in adults with leucocyte counts around from 10,000 to 12,000. Splenic anæmia was designated by many of the early observers splenic pseudoleucæmia, and it is believed by some clinicians of the present day that von Jaksch's disease (infantile pseudoleucæmia) is an infantile form of splenic anæmia in which a moderate leucocytosis due to the higher values of leucocytes in the normal blood of infants is to be found.

A number of pathologic conditions of the spleen which more or less resemble splenic anæmia have been classified as splenic anæmia, especially that of syphilitic splenomegalia. A few clinicians regard all splenic anæmias as syphilitic in origin, but this theory is not borne out by our experience. Chronic enlargements of the spleen that are accompanied by anæmia and are the result of various protozoa, syphilis, malaria, kala-azar, etc., as well as those anæmias due to bacteria, typhoid and tuberculosis, were removed from the splenic anæmia group when their etiology was discovered.

Hæmolytic icterus has often been confused with splenic anæmia. Occasionally pernicious anæmia, when accompanied by a large spleen, has been diagnosed splenic anæmia. Put in the form of an Hibernianism, incomplete knowledge is essential to the diagnosis. If we know the cause of splenic anæmia it is not splenic anæmia. It is a question, however, whether we have not been too insistent on the lack of knowledge as evidenced by unknown etiology as one of the chief features of splenic anæmia. I believe we would get a much better idea of splenic anæmia if we made the pathologic condition of the spleen and its effect on the blood the criteria, and classified as splenic anæmia all cases of known causation as well as those of unknown causation, assuming that in the course of

* Read before the American Surgical Association, June 18, 1919.

time we shall find the toxic agents which produce the condition of the spleen.

The pathologic characteristics of the spleen in splenic anæmia are generalized fibrosis with compression atrophy of the malpighian corpuscles, and endophlebitis. It may be said that enlarged spleens that show such characteristics will develop chronic anæmia without regard to causation. In five instances we removed large spleens in cases of chronic intractable syphilis with severe anæmia in which the patients had been carefully treated for syphilis for months. After the removal of the spleen, the anæmia rapidly disappeared and the syphilis was cured with comparatively mild antiluetic treatment, such as had previously failed to affect either the syphilitic condition or the spleen. In three of these cases gummas were found in the liver, in two, small gummas were found in the spleen, and in two the spirochæte was stained in the splenic tissues.

In 1883 Banti first described an enlargement of the spleen accompanied by atrophic cirrhosis of the liver of the Laennec type. The relation of splenic anæmia to Banti syndrome is most interesting. The majority of clinicians, I believe, agree with Moschcowitz in the conclusion that there is no real difference between the two and that Banti's disease is merely a late phase of some cases of splenic anæmia. It is certainly true that a considerable percentage of cases of splenic anæmia in the later stages will be found to be associated with portal cirrhosis of the liver, but not always of the atrophic type; the liver is as frequently enlarged as contracted. On the other hand, some observers believe that all cases of this description are primarily portal cirrhosis and that the splenomegalia is secondary. When the condition is seen in the later stages, it is difficult, if not impossible, to determine whether it was primarily portal cirrhosis with secondary splenic manifestations, or primarily splenic anæmia.

Gastro-intestinal hemorrhages, especially hæmatemesis, and ascites occur in splenic anæmia and in portal cirrhosis. After all, cirrhosis of the liver is essentially a fibrosis which exhibits more fixed characteristics than the spleen because the liver cells are all of one type and react uniformly to chronic irritation, while the spleen has differentiated groups of cells which permit of wide architectural changes. It is also to be noted that the blood comes directly in contact with the splenic pulp, as the vessels retain only their endothelial coverings; this may account for the endophlebitis, which is so marked a characteristic of splenic anæmia. Occasionally an enlarged spleen will be found, especially in women, without known cause and without anæmia. This condition may exist for years, but eventually anæmia results. In several cases of this type, when the patients finally came to operation, the spleen was fibrotic. It is probable that fibrosis of the spleen from any cause will eventually produce chronic anæmia and, other things being equal, such spleens should be removed when appropriate treatment fails to cure.

Of sixty-one patients with splenic anæmia from whom we removed the spleen seven (11.7 per cent.) died.¹ The deaths occurred in patients operated on in a late stage of the disease, in which there was a high grade of anæmia, ascites, and cardiorenal manifestations. In three patients acute thrombosis of the superior mesenteric and portal veins was the immediate cause of death; extensive thrombosis, evidently of long standing, was found in the splenic veins. These observations are in accord with those of Dock and Warthin, who found extensive thrombosis of the splenic vein in two patients who died from splenic anæmia and in which there was ascites without cirrhosis of the liver. It would appear that the spleen, acting as a filter, removes noxious agents, both microorganisms and chemical toxins, from the blood stream and sends them to the liver for destruction; in certain instances cirrhosis of the liver as well as fibrosis of the spleen results from the chronic irritation produced by such substances. If the spleen is unable to rid itself of all these toxic agents, splenomegalia and anæmia result with sequestration of the agents in the spleen, as in spirochætal and plasmodial infections, but the liver is not necessarily cirrhotic. Why the liver is cirrhotic in some cases and not in others is not known.

Both portal cirrhosis and splenic anæmia lead to death through portal obstructions, and the hemorrhages and ascites are due to back pressure. If the spleen is removed early in splenic anæmia, we know by experience that the liver will probably not show serious evidences of disease later, and even when cirrhosis of the liver is well marked and ascites is present, removal of the spleen often effects a "near" cure. The first thought is that by removing the spleen toxins filtered from the blood are prevented from passing to the liver. On further consideration it seems that the true explanation is this: Inasmuch as the normal spleen carries about 30 per cent. of the blood to the liver and that from these huge spleens the splenic vein may carry as much blood to the liver as the remaining elements of the portal vein, splenectomy relieves the liver of its overload and reduces its labor sufficiently to enable it to meet its demands, just as sometimes follows the Talma-Morison-Drummond operation. Fagge, many years ago, described a series of cases in which persons apparently in perfect health, coming to their death by accident, proved at necropsy to have advanced cirrhosis of the liver, but with so good a compensatory circulation along the vascular channels of Sappey as greatly to reduce the circulation in the liver and enable it to maintain its function.

Many patients splenectomized in the late stages of the disease with marked ascites and frequent hemorrhages from the stomach, etc., have been cured. Balfour, in a recent article on gastric hemorrhages of splenic origin, reports in detail a case in which the removal of a spleen a

¹ These statistics extend to December 31, 1918, and include as operative deaths all patients dying in the hospital without regard to cause of death or length of time after operation.

THE RESULTS OF SPLENECTOMY IN THE ANÆMIAS

little larger than normal, checked gastric hemorrhages of many years duration, from which the patient was almost exsanguinated. The patient has remained well for nearly three years. We have since had a similar experience. A patient in extremis for whom repeated blood transfusions failed to afford even temporary relief was cured by splenectomy. Sherren and others have called attention to the fact that after the removal of the spleen for splenic anæmia an occasional patient has a recurrence of hemorrhages. We have had one case of this kind, but such experiences are unusual. I would call attention to the important fact that in five of these cases the diagnosis of splenic anæmia was not definitely established, but the five cases fitted into this group better than into any other. Future progress in knowledge of splenic conditions may change the interpretation of the facts and alter the diagnosis.

PERNICIOUS ANÆMIA

The etiology of pernicious anæmia is unknown, the early symptoms are indefinite, and by the time the diagnosis can be made the disease is incurable. The disease may be described as a progressive degeneration of the red blood in which there is a loss of the blast or mother cells of the erythrocytes; the blast cell when lost is not replaced. In contrast to splenic anæmia which is of the secondary type, the blood picture in pernicious anæmia has characteristic cells which mark the disease. The color index, or hæmoglobin percentage, is higher in proportion to the number of red cells present than in the secondary anæmias. The lemon color of the skin, sometimes with an icteroid hue, is so different from that in the secondary anæmia that sometimes a diagnosis is possible by looking at the patient. This icteroid hue is more prominent in cases in which hæmolysis is marked, as shown by examination of the duodenal content after the Schneider method. If we might assert that in cases of pernicious anæmia in which hæmolysis is most marked patients have a greatly enlarged spleen or that the spleen exhibits definite pathologic changes, we would have succeeded in establishing a direct connection between the enlarged spleen so often found and the disease. Unfortunately, our experience does not support this hypothesis, and the size of the spleen does not seem to bear a definite relationship to the severity of the disease. Necropsy, after death from pernicious anæmia, as a rule shows a small spleen, but in two only of our cases was the spleen below normal (195 grammes, Sappéy) at operation, and both were terminal cases.

The average weight of the spleens removed in our cases of pernicious anæmia was 400 grammes, exclusive of two large spleens, one of which weighed 2220 grammes and the other 1600 grammes. It seems probable, therefore, that in pernicious anæmia the spleen is enlarged during the early and middle stages, and that the contraction so often found at necropsy is a terminal condition. The question is as yet unanswered whether per-

pernicious anæmia is a definite and specific entity, or whether it is a terminal change of several conditions, and recognized only as pernicious anæmia when the patient has reached a stage which we know will eventually cause death.

Any form of treatment for pernicious anæmia may prove, or at least may appear to be, beneficial. Even without treatment these patients have their ups and downs, and it is not an infrequent clinical experience to have a patient present himself with symptoms which might be construed as being those of an early pernicious anæmia, and then with or without treatment recover and remain well. In eliciting the history the physician finds that the symptoms are often indefinite in the earlier stages, before the blood changes become characteristic.

Splenectomy in pernicious anæmia does not appear to be based on sound reasoning and there seems to be no foundation for the belief that the procedure will cure pernicious anæmia. Eppinger first suggested splenectomy as a cure for pernicious anæmia, and the early reports with the abundant testimony as to temporary relief were quite sufficient to give the operation a fair trial in this hopeless disease. Considering the confusion which so often attends the early diagnosis, it seems probable that obscure cases of hæmolytic icterus and splenic anæmia have been accidentally included in the pernicious anæmia group. Removal of the spleen in such cases has given the impression that splenectomy cures pernicious anæmia. At the same time in the investigation of our cases of splenectomy for pernicious anæmia, we see great, though temporary, improvement. There is a gain in weight, and an improvement in the blood from an average hæmoglobin of 38 to 72 per cent., and the reds from two to four millions. Splenectomy seems at least to have instituted a marked palliation.

In our experience in the cases in which the results were most favorable the symptoms were less characteristic of pernicious anæmia. In young and middle aged persons in whom the disease is most rapid, especially if hæmolysis is known to be marked, splenectomy is worthy of trial. Taken as a whole, it may be said that whenever pernicious anæmia has developed to the stage in which the blood is characteristic it is incurable, and splenectomy is a means of palliation and not of cure. Since there is an operative mortality good reasons must exist for substituting operation for repeated blood transfusions. We have splenectomized 50 patients with pernicious anæmia with three deaths (6 per cent.).

HÆMOLYTIC ICTERUS

Hæmolytic icterus has not been classified with the anæmias, but as pointed out by Kanavel and Elliot, the peculiar splenic activity results in an anæmia which is the cause of death. As in splenic and pernicious anæmias, the etiology of hæmolytic icterus is unknown. The well devel-

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oped hæmolytic icterus stands out with a vividness, unequalled in splenic anæmia and in pernicious anæmia. These three diseases, all of unknown etiology and lacking sound pathologic foundation, when examined in the minutiae are without distinctive features. Viewed in the perspective they are outstanding clinical entities. The characteristic features of hæmolytic icterus are an enlarged spleen, chronic jaundice with exacerbations, normally bile colored fæces, and absence of bile in the urine.

It is certain that in hæmolytic icterus the spleen destroys, unnecessarily, the red corpuscles; the enlargement of the spleen may be in the nature of a work hypertrophy. Enlargement of the liver is usually present and may also be a work hypertrophy. In some of our cases sections from the liver showed definite hyperplasia of liver cells.

There are two types of hæmolytic icterus, the familial or congenital type of Minkowski, and the acquired type of Hayem and Widal. In the familial type the disease may be noticed from infancy and it may not be progressive; the patients live the allotted span of years in a fair degree of health, but with more or less jaundice throughout life. These cases are not uncommon and are to be seen in every community; a large percentage develop a more serious condition which makes them indistinguishable from the acquired type, and like the acquired type, the disease progresses in the course of some years to a fatal ending.

Chauffard and Widal have pointed out that the red cells are less resistant in hæmolytic icterus than normally, and our experience confirms these observations. Sanford has worked out a simple and very reliable method of examination for red cell fragility which we have used in the clinic extensively and with great satisfaction.

THE RELATION OF HÆMOLYTIC ICTERUS TO THE LIVER AND ITS CIRRHOSIS

We find in hæmolytic icterus an occasional case in which biliary cirrhosis is associated. Brushing aside the familiar classification of the cirrhoses of the liver in which variations in the morphology lead to unnecessary confusion, there are but two fundamental hepatic cirrhoses: (1) The portal, in which the toxic material reaches the liver by way of the portal vein, and in which the connective tissue is deposited about its radicals and death is caused by portal circulatory obstructions, ascites, gastro-intestinal hemorrhages without jaundice until shortly before death, etc., and (2) biliary cirrhosis, caused by an infection of the biliary ducts in which the connective tissue is deposited about the biliary ducts causing jaundice but without ascites or hemorrhages until shortly before death. More often this is an ascending infection from associated gall-stone disease, especially gall stones in the common duct; at times it is hæmatogenous from focal infections in any part of the body; the pancreas is frequently associated in a chronic pancreatitis. Just as we have many varieties and subvarieties of portal cirrhosis, so we have many varieties

and subvarieties of biliary cirrhosis, but we should not be led astray by the many patterns which may appear any more than we should name wall-papers or carpets differently according to their patterns. Normally blood pigments are the source of the coloring matter in the bile. In hæmolytic icterus the enormous destruction of red corpuscles in the spleen inundates the liver with blood pigments, and renders the bile thick. One can conceive that, under such circumstances, a liver which has a superabundance of work of a certain kind thrown upon it may deposit pigments throughout its tissue, thus producing many of the patterns which are given as varieties of biliary cirrhosis. As there is no infection there is no cirrhosis, but there is, as I have stated, some enlargement of the liver.

The viscid bile in hæmolytic icterus tends to form gall stones. Sixty per cent. of all the patients with hæmolytic icterus on whom we operated had associated gall stones and all the possibilities of biliary duct infection. It may readily be understood why biliary cirrhosis is sometimes associated with hæmolytic icterus and why the two diseases have been confused. It should not be forgotten that in portal cirrhosis and in biliary cirrhosis the entire liver may not be involved in the cirrhosis. We frequently see limited areas of cirrhosis without attending symptoms because the organ is not extensively involved. Hæmolytic icterus has been most often confused with the elusive syndrome termed Hanot's cirrhosis, which, so far as I know, has no pathologic foundation, and if it occurs clinically I have never seen it.

The triumph of splenectomy is the cure of hæmolytic icterus. We have had no more satisfactory results in surgery than are to be found in this group of cases. Only patients in a terminal condition with secondary gall stones and cirrhosis of the liver fail to be relieved. The only patient we lost of the twenty-seven splenectomized for hæmolytic icterus was one operated on during an acute exacerbation. Crises are a part of the picture of the disease, and when severe have usually been due to gall stones, although it is undoubtedly true that exacerbations do take place from unknown causes in which there is great but temporary increase of jaundice, with tenderness and increased tumefaction of the spleen and usually of the liver, without gall stones. On gross section the spleen in hæmolytic icterus is dark, mottled, filled with blood pigments, and quite distinct from the spleens which we have removed for other conditions.

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THE TREATMENT OF GUNSHOT WOUNDS OF THE CHEST *

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THE symptoms of gunshot wounds of the lung, in those who survive the initial hemorrhage, need no special description. Here, as in other parts of the body, the development of subsequent infection depends largely upon the nature of the wound. In civil surgery, perforating wounds in which the missile escapes, and penetrating wounds in which the missile lodges in the lung, frequently heal without incident. In war surgery an equally satisfactory course may be expected in corresponding wounds the result of machine-gun bullets. On the other hand, fragments of high explosive shells, the cause of many pulmonary wounds, are frequent carriers of infectious material which may or may not be removed in the act of penetration by contact with the soft tissues of the chest wall. In all varieties of gunshot wounds of the chest, whatever the type, but more especially in those due to a high explosive agent, an associated hæmothorax materially increases the likelihood of infection, for the resistance of the patient is diminished by the actual loss of blood, usually amounting to between one and two litres, and by the respiratory and circulatory embarrassment which result from the pressure of the pleural contents on the lung and heart, while the clotted blood itself provides a favorable culture medium for whatever pathogenic organisms may have been introduced.

All of the cases reported in this paper were complicated by a hæmothorax which required either aspiration or thoracotomy, and the selection of these cases was made because of the belief that, of all chest wounds, in this particular group, if in any, radical rather than conservative treatment would seem to have been justified. They would appear, therefore, to serve most appropriately as a basis for the discussion of the relative value of these two methods of treatment.

For the purpose of such consideration, these wounds may conveniently be divided into perforating and penetrating. In the former group, an expectant plan of treatment has proved, in the opinion of all surgeons, more desirable than radical measures. Four cases of this character, herewith reported, required aspiration of the associated hæmothorax. This was done forty-eight (two cases) and seventy-two (two cases) hours, respectively, after the receipt of the injury. The amount of blood removed varied from an ounce and a half to one and one-half quarts. The relief of subjective and objective symptoms, indicative of circulatory and respiratory embarrassment, was generally immediate and satisfactory. In

* Read before the American Surgical Association, June 16, 1919.

Case IV, the relief of dyspnoea and pain through the withdrawal of only one ounce of blood would point to pleuritic reflex irritation rather than to pressure as a probable etiological factor of the symptoms mentioned. All four cases recovered and were evacuated in seven days after all respiratory embarrassment had disappeared.

Penetrating wounds include those with the lodgment of a foreign body in the pleural cavity and those complicated by the retention of fragments in the lung itself. Of the former there were several instances which are not included in this report, as in none was aspiration necessary. If the projectile is impacted in the pleural opening and can be reached in the course of the débridement of the external wound, its removal is preferable. Care must be taken, however, during the necessary dissection to prevent the accidental detachment and subsequent escape of the foreign body to an inaccessible part of the pleural cavity either by firmly grasping it with a tenaculum or by passing a needle beneath it, for it is quite like the joint mouse in its lack of toleration of restraint.

The removal of foreign bodies that have already reached a portion of the pleural cavity remote from the wound of entrance, should be attempted only in case they cause undue irritation or lead to infection. Their successful removal usually requires extensive exposure, a procedure which, in view of the proximity of the usually infected wound of the chest wall, may readily lead to infection of the entire pleural cavity. In this group of cases, as well as in the much more common group in which it has lodged in the lung, the surface of the fragment seems at times to have been cleansed of infectious and foreign material by contact with the divided soft parts of the chest wall, for while the extra-thoracic path of the projectile frequently becomes infected, the portion lying within the pleural cavity or the lung generally escapes.

The second and by far the most frequent group of penetrating wounds of the chest includes those in which the projectile has lodged in the lung tissue. The question of its immediate removal from this location or of leaving it undisturbed has been a subject of frequent debate.

Of the 15 cases of this character, herewith reported, in which the associated hæmothorax required aspiration, 13 recovered and 2 died. Of the latter one had already developed a serious pleuritic infection prior to admission to the hospital, while the other was complicated by a pericarditis. In neither did the condition of the patient warrant intervention. Those who recovered were evacuated after the complete subsidence of all pulmonary symptoms, usually at about the tenth day, and in none before the expiration of a week. Apart from the relief of the associated hæmothorax, which, in two instances, required a thoracotomy under local anæsthesia on the fifth and sixth days, respectively, the treatment was conservative and the patients were evacuated with the projectile still *in situ*. The thoracotomy was done only after two attempts to aspirate had failed. In all of these cases, as in the four instances of perforating

wounds, aspiration promptly relieved both the pain and dyspnoea. No infection developed, although aspiration, and especially thoracotomy, done under conditions of war surgery, might easily lead to that complication.

Aspiration was usually done on the second or third day when it was evident that the circulatory and respiratory disturbances were not subsiding, and an average of from one to one and a half litres of bloody serum was removed. In one instance, after the removal of one and one-half litres of blood at the end of forty-eight hours, two additional litres of blood-stained fluid were removed five days later. In the interval there had been no indication of hemorrhage, and the character of the aspirated contents pointed to the original bleeding as the probable source of the "recurrence." In no instance was aspiration followed by a renewal of the hemorrhage, a fact that appears to controvert the theory that the removal of a large quantity of pleural contents predisposes to subsequent bleeding. To remove only a small portion of the extravasated blood in hæmothorax at any one time is therefore unnecessary as well as undesirable, for repeated aspirations at frequent intervals are doubtless harmful to patients in a depleted condition who are fighting for breath and suffering from a lack of adequate circulation.

Apart from aspiration, the question of the immediate removal of the fragment from the pulmonary tissue has been, as already mentioned, the subject of considerable debate. Its immediate removal is unquestionably associated with a much higher mortality than allowing it to remain undisturbed, which may well be ascribed to a condition of lowered vitality and therefore of diminished resistance, due to one or more of the following factors: To exposure before and after the receipt of the injury; to insufficient nourishment; to the associated hemorrhage, either externally or into the pleural cavity; to the transportation to the hospital, which is rarely reached before the expiration of from six to twenty-four hours. Furthermore, the risk of an attempt to remove the foreign body is increased still more by the formidable character of the operation, which, together with the added inevitable loss of blood, is, in view of the general condition of the patient, sufficient to determine a fatal issue. Finally, the exposure of the lung, essential to the removal of a foreign body therein located, establishes a large communication with the already infected portion of the wound in the chest wall and thereby predisposes to the extension of the infection into the pleural cavity.

On the other hand, by conservative treatment, opportunity is afforded for almost complete restoration of vitality, and if the development of infection or, later on, the continued irritation of the foreign body justifies operation, it may be done under much more favorable conditions and with much greater chance of success. Although as yet the writer has seen no publication of pathological conditions arising from infection proceeding from the retention of high explosive fragments in the lung, it is reasonable to infer that the resulting abscess would be circumscribed

and that its contents would either spontaneously discharge into a bronchus or else, approaching the chest wall, would result in a localized empyema, in which event the opening of the abscess and the removal of any foreign material which it might contain could be easily and safely accomplished. As a matter of fact, several cases which followed this favorable course were observed by the writer in base hospitals around Tours.

The cases herewith reported, although small in number, indicate that immediate infection is uncommon. In one instance infection had already developed prior to the admission of the patient, and was unquestionably chiefly responsible for his death. Unfortunately none of the other patients who recovered were evacuated to any of the hospitals to which the writer was subsequently assigned as consultant, and therefore the final results cannot at present be determined. The writer has learned in a general way from those colleagues in whose care some of these patients were placed, that their further course was quite satisfactory and that the removal of the retained foreign bodies did not prove necessary. This fact strengthens the contention that pleuritic or pulmonary infection is unlikely to develop in patients who remain free from such infection for a period of ten days after the receipt of the injury. Whether infection will subsequently occur in the pulmonary tissue adjacent to and inclosing the projectile can only remain a matter for conjecture. The susceptibility of the lung to infection, as compared with other organs, presents a most interesting topic for investigation. Yielding easily, for example, to the tubercle bacillus, is it more or less resistant to other organisms, especially to those of a pyogenic character? Whatever the actual explanation, it seems reasonable to infer that, as a general rule, fragments of high explosive shells, many of which originally carried agents of infection, will remain in the lung quiescent, indefinitely.

Of the open sucking wounds of the pleura no mention has been made. The desirability of their closure at the earliest opportunity is undisputed. This closure to avoid tension should be made when necessary by the insertion into the opening of a musculo-aponeurotic flap in order that the reopening of the pleural cavity may be avoided, a condition which seriously threatens the life of the patient.

In conclusion attention is directed to the serious character of infection attacking an entire pleural cavity and its lack of resistance in comparison with the peritoneum. One instance of this kind has already been mentioned in which, after forty-eight hours, the death of the patient occurred, and several other instances of similar infection, due to the penetration of foreign bodies, have been observed by the writer in civil practice. This condition is best treated by prompt and relatively protracted drainage at the most dependent angle of the pleural cavity, a counter-opening being made for that purpose whenever necessary.

The writer wishes to acknowledge his indebtedness to Captain Harold

F. Budington, of Springfield, Mass., for his kindness in the preparation of the abstracts of the histories of these cases and for his conscientious care of the patients themselves.

PERFORATING WOUNDS OF THE CHEST

CASE I.—Machine-gun bullet from outer end of right clavicle to lower end of right scapula. Aspiration forty-eight hours later withdrawing half a pint of serous fluid, followed by immediate relief of sense of weight and pressure over chest with improvement in breath—only slight cough and no dyspnoea except on exertion.

CASE II.—Machine-gun bullet from third rib anteriorly to ninth rib posteriorly on right side at a point two inches below angle of scapula. Aspiration of 6 ounces of bloody fluid forty-eight hours later on account of dyspnoea cough with bloody expectoration. Immediate relief of these symptoms followed. Evacuated in good condition at the end of a week.

CASE III.—Shrapnel wound entering upper right chest below outer end of clavicle, the wound of exit being in the back on the same side. Dyspnoea and rusty sputum. Aspiration at the end of seventy-two hours withdrawing one and one-half quarts of bloody fluid with marked relief of the dyspnoea. Evacuated later in excellent condition.

CASE IV.—Shrapnel wound below middle third of right clavicle, foreign body being located a short distance beneath the skin near the inferior angle of the scapula, from which point it was removed by a counter-incision; seventy-two hours after receipt of injury one ounce of clotted blood removed by aspiration, followed, notwithstanding the small amount, by relief of both the dyspnoea and pain. Evacuated in excellent condition one week later.

PENETRATING WOUNDS OF THE CHEST

CASE V.—Shrapnel wound just below left clavicle near the shoulder, X-ray disclosing the shadow of a foreign body moving with respiration. Patient was suffering from marked shock and dyspnoea. Forty-eight hours after injury, one quart of bloody fluid removed by aspiration from the left pleura followed by considerable improvement in cyanosis and respiration. These symptoms, however, together with the physical signs of fluid still persisted, the bloody expectoration becoming mucopurulent. On account of the persistence of dyspnoea a second aspiration was done seven days after the receipt of the injury, removing two quarts of dark bloody serum. For two days prior to the second aspiration the patient's temperature was between 104° and 105°, thereafter gradually diminishing to normal. Patient evacuated on fourteenth day, in good condition with ing. Evacuated at end of week in excellent condition.

CASE VI.—Shrapnel wound with point of entrance in left anterior axillary line two inches below the nipple, X-ray showing a small

foreign body near the left nipple moving with respiration. There was severe coughing and dyspnoea, due at least in part to mustard gas burn of face and respiratory tract. Twenty-four hours after receipt of injury withdrawal of clotted blood by aspiration. Four days after receipt of injury aspiration was repeated. As only a small amount of clotted blood was removed and both pain and a dyspnoea continued, a thoracotomy was done by Doctor Budington under cocaine on the following day, removing a considerable amount of clotted blood and slightly blood-tinged serum, drainage being provided for a time with a rubber tube. Improvement of all symptoms with evacuation in ten days, the patient at that time only coughing spasmodically.

CASE VII.—Multiple shell wounds, involving arms, legs, neck, abdomen and posterior part of chest, the point of entrance in this last mentioned site being near the lower border of the ribs in the anterior axillary line. There was intense shock with cough and dyspnoea. Four days later, the dyspnoea was relieved by the aspiration of one quart of bloody fluid, the patient being evacuated subsequently in excellent condition.

CASE VIII.—Shrapnel wound of right chest, point of entrance being in the posterior axillary line below the angle of the scapula. There was cough, dyspnoea and bloody sputum. Two days after the receipt of injury, a half pint of sero-sanguineous fluid was aspirated with relief of both dyspnoea and pain. Evacuated in good condition.

CASE IX.—Shrapnel wound with point of entrance in the right posterior axillary line on a level with the inferior angle of the scapula. X-ray showed foreign body moving with respiration. There was marked emphysema with pneumohæmothorax and constitutional symptoms of infection. On the third day one and one-half quarts of foul bloody fluid with much air were removed by aspiration. Although relieved somewhat of pain and dyspnoea, the septic condition continued unabated, the patient dying on the following day from the original hemorrhage and sepsis. In this patient an immediate thoracotomy under a local anæsthetic might have proved of value. It was not done owing to the serious nature of the patient's general condition.

CASE X.—Foreign body with point of entrance in the back of left chest penetrating both the pericardium and the left pleura, and seen on X-ray to move with the heart. The physical signs indicated an increasing amount of the fluid contents of both serous spaces, and forty-eight hours after the receipt of injury one and one-half quarts of bloody fluid was withdrawn from the pleural cavity. The patient was evidently progressing satisfactorily when death suddenly occurred eight hours later from cardiac failure. Unfortunately no autopsy could be made.

CASE XI.—Shrapnel wound of left chest with marked hæmothorax. Three days after receipt of injury a small amount of clotted blood was removed. Two days later, as marked cyanosis

continued and another attempt to aspirate failed, a thoracotomy was done by Doctor Budington under cocaine with immediate great relief of dyspnœa and disappearance of the cyanosis. Evacuated on the twenty-seventh day in excellent condition.

CASES XII, XIII and XIV present no special features of interest. In all one quart of blood was removed on the third (two) and fourth days, respectively. All recovered and were evacuated in satisfactory condition.

CASES XV, XVI, XVII and XVIII.—These patients recovered and were evacuated, but neither the amount of blood removed nor the time of aspiration are mentioned in the history abstracts.

THE DELAYED OR LATE EXTRACTION OF INTRATHORACIC PROJECTILES BY THE METHOD OF PETIT DE LA VILLÉON *

BY ROBERT G. LE CONTE, M.D.

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THIS method was developed, shortly after the beginning of the war, by radiologist Le Coniac and surgeon Petit de la Villéon at the French Naval Hospital at Brest, and since their departure the work has been continued by Doctors Corolleur and Robin with equal success.

The method depends upon the localization of the projectile with regard to its anatomic surroundings, in contradistinction to its mathematical situation from surface markings. The localization is made through the fluoroscopic screen and not by pictures, and the extraction is also made by sight with the aid of this screen. The anatomical localization is made with the patient standing, and the permanent situation of the shadow of the projectile by frontal and lateral examination will indicate its intrathoracic position. For example:

(1) The displacement of the shadow downward during inspiration, following the diaphragm, and upward during expiration, *i.e.*, in reverse direction to the movement of the ribs, shows that the projectile is in a freely moving lung.

(2) If the shadow follows the movement of the rib, the foreign body is in the lung adherent to the rib or in the pleura.

(3) When in that portion of the lung which lies in the costodiaphragmatic angle, by turning the patient there will always be a position in which the projectile will be viewed clearly between the shadows of the diaphragm and the thoracic wall, and separate from these shadows.

(4) If the projectile is in the cul-de-sac and adherent to the pleura, it will follow the movement of the ribs or diaphragm, to whichever it is adherent.

(5) The projectiles on the dome of the diaphragm are localized without difficulty, but where the shadow of the foreign body is continuous with the shadow of the diaphragm, the question of anatomical localization is difficult, for it may be imbedded in the diaphragm, or sub- or supra-diaphragmatic. Sometimes its exact localization cannot be determined without an exploratory operation, either by the abdominal or thoracic routes.

(6) When the shadow is in the quadrilateral space bounded by the internal borders of the scapulæ and the fourth to the eighth ribs, its anatomical position with regard to the great vessels and large bronchi at the root of the lung is most important. On a lateral view the hilum

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of the lung will be between the plane made by the anterior portion of the bodies of the vertebræ and the posterior shadow of the plane of the heart. If the shadow of the foreign body lies posterior or anterior to this space, the projectile is imbedded in the lung at a safe distance from the hilum, and may be readily extracted without danger, no matter what its depth may be from the costal margin. Above the fourth rib and below the eighth rib it is also in an easily accessible region. Extractions from the hilum of the lung will be discussed in a later paragraph.

(7) In the left chest the relations of the "éclat" (shell fragment) to the pericardium and heart must be exactly determined, and if it moves with the heart beats and fails to move with respiration, extraction by means of the fluoroscope should not be attempted, and an open operation is indicated.

After the standing examination, the patient is examined lying down, to verify the information already obtained. While this anatomic localization is being made, the route by which the extraction will be made is also carefully considered, especially with regard to the tissues that must be traversed to reach the projectile. The shortest route is not always the best, and a lateral or oblique approach is preferable, because it gives to the hand of the operator, held in a horizontal position, greater freedom of motion for manœuvring the forceps, and permits a constantly clear view of the projectile and the end of the forceps in the fluoroscopic light.

This method depends, therefore, upon the exact anatomical localization of the projectile, and upon its extraction with forceps through the smallest of openings, in which the tip of the forceps is constantly in sight, and its guidance to the foreign body is directed by the change in relation of the shadow of the forceps and the shadow of the projectile, the patient lying on a movable table. Whichever of these objects lies nearest the tube, the larger will be the arc of its movement on rotating the patient.

To one who has not seen the method practised by a master hand, the operation may seem uncertain and hazardous. I had this feeling before making my first visit to l'Hôpital de la Marine de Brest, but I left the hospital a thorough convert to the method. Later I was permitted to make some extractions of foreign bodies from the extremities. In this institution about 4000 projectiles have been removed from various parts of the body by this method. In the extremities these extractions were so easy and rapid that it led Petit de la Villéon to try it in the lung. This was done for the first time October 27, 1915, with perfect success.

Technic of the Operation.—The patient is bound to a table, the surface of which can be rotated on its long axis, with the X-ray tube beneath, and an iris diaphragm for the concentration of the light on a given point. The patient is anæsthetized while the room is light. The lights are then turned off, and when the pupil has reacted to the darkness, the X-ray is turned on, the projectile inspected, and the point of approach noted on

the skin. The light is turned on, and with a bistoury a small stab opening is made to the pleura, just large enough to admit the forceps. The point of the forceps is placed in this cut, the lights are shut off and the X-ray turned on. By gentle pressure the closed forceps are forced toward the projectile, and the two shadows are correlated by movements of the table. When the "éclat" is reached it is gently freed from its bed of surrounding tissue with the closed blades of the forceps, and when completely movable the forceps are opened and the object grasped in such a manner that any existing sharp edges or points will cause no damage to the surrounding tissue during the extraction. After the removal, the pleura is carefully inspected for a moment or two for hemorrhage. The light is turned on and the wound dressed with sterile gauze. The technic is simple but highly specialized, and three things are essential for the successful practice of the method.

1. The radiosopic eye must be acquired.
2. The correlation of the two shadows made by the foreign body and the point of the forceps. This must be intuitive, without process of thought, as a dentist works by mirror or direct sight.

3. Gentleness and dexterity of the hand. This is acquired by the removal of projectiles from less dangerous zones, as in the extremities.

The principle underlying the success of this method depends on the fact that a closed forceps can be made to traverse a healthy lung without injuring the vessels or bronchi, as these important structures will be pushed aside when gentle force is used. The danger from hemorrhage will come during the extraction, when the projectile is considerably larger than the diameter of the forceps, or its cutting edges are not protected by the blades of the forceps. The passage through the lung to the projectile must be a straight one, and the making of V or Y passages must be avoided. For superficial foreign bodies, an ordinary hæmostatic forceps is used, but for those lying deeply in the lung the alligator jaw forceps is preferable. The forceps should snugly fit the opening through the thoracic wall, to avoid the production of a pneumothorax, for with air in the pleura a freely moving lung slips away from the forceps. In the hands of an expert two or three minutes will suffice for the removal of superficial "éclats." Those imbedded in the depth of the lung will take a little longer time.

Anæsthetic.—The patient is put to sleep with the lights on, but during the operation the anæsthetic is continued in the dark. The French use ethyl-chloride in a closed inhaler for short operations, but if the operation is prolonged beyond a few minutes they add chloroform. In the United States ether will be preferred to chloroform, but it must be remembered that it is slightly more irritant to the lung. The absence of light requires an experienced anæsthetist.

The Incidents During Extraction.—A little air may enter the pleura through the cutaneous opening with a slight whistling noise. Slight

hæmoptysis may occur, or the patient's saliva be mixed with blood. Slight hemorrhage into the pleura from the zone of extraction is not infrequently observed. It will be seen through the screen as a light shadow the size of a quarter, which may increase to the size of a dollar. This should be observed for a sufficient period of time, to be assured that a rapid hæmothorax is not developing. All of these incidents in Robin's capable hands were without importance.

After Care.—The patient is put to bed and given a sixth of a grain of morphia and an injection of antitetanic serum. In war wounds all deep scar tissue or imbedded projectiles are potential harbors of tetanus bacilli. During the first twenty-four or thirty-six hours there is usually a slight elevation of temperature. Coughing is prevented or controlled by codeine. The expectoration will be tinged with blood for two or three days. Sometimes a little subcutaneous emphysema will develop around the wound. In a week the patient is out of bed. It may then be noted that there is a slight diminution of respiratory movement, due perhaps to pleural adhesions or to pain in the region of the wound. Respiratory gymnastics should then be used. At the end of a month the patient is ready to leave the hospital.

Projectiles in the Hilum.—The removal of foreign bodies from this region of the lung will always be attended with danger, no matter what method of operation is employed. The localization of the "éclat" in this area has already been described, and careful consideration must be given to the route by which the extraction will be made. As the first step in this operation a portion of one rib is resected, and the pleura incised for an inch or more in extent. Should hemorrhage occur after the extraction, the field for controlling it with a gauze pack is prepared in this way. When the projectile lies in the posterior half of the hilum of the lung, a posterior thoracotomy is done, and after opening the pleura an alligator jawed forceps is carefully guided to the projectile under the fluorescent screen. If hemorrhage occurs, it is controlled by packing and the wound left open. If it does not occur the incision in the thoracic wall is closed by suture.

The dangerous zones from which projectiles should not be removed by this method are the mediastinum, pericardium, heart, the medial region of the diaphragm, and the left diaphragm, unless the missile is clearly supra-diaphragmatic. In these regions an open operation is safer, when it is deemed advisable to remove the projectile.

Statistics.—During the October, 1918, meeting of the Congress of French Surgeons, Petit de la Villéon reported about 330 and Robin 92 extractions of foreign bodies from the chest. There were four deaths in these combined series, a mortality of a little less than one per cent. One death was apparently due to the anæsthetic, and one occurred from sepsis, in a patient who had previously had an open operation on the opposite lung, and the autopsy disclosed a putrid gauze pack in the pleura. I can only

analyze Robin's 92 extractions, as Petit de la Villéon's statistics are not available for the moment. The above case with the putrid gauze pack was Robin's only death. Three of his cases developed hæmothorax. (1) The hemorrhage reached the level of the seventh rib, and recovery followed without operative interference at the end of a month. (2) The hemorrhage was more profuse, requiring three aspirations of 200, 250, and 800 grammes of blood. Recovery followed without further incident, beyond a stay of four months in the hospital for pulmonary gymnastics. (3) A small localized hemorrhage developed into an empyema requiring a costal resection for drainage. Recovery followed in three months. One other case developed an empyema on the twelfth day without previous hæmothorax, and recovery followed the excision of a rib. The danger of purulent pleurisy is not from the exterior, as in an open operation, but from the interior, when infection exists in the tissues surrounding the projectile. That this danger is infrequent is shown by Robin's statistics. Theoretically its infrequency may be explained by the rapid closure or sealing of the punctured wound in the lung, and the draining of the infected cavity by a bronchus. Such drainage would probably be unnoted in the sputum, but that it can occur would be shown by the hæmoptysis which frequently follows the extraction. It may, therefore, be an added factor of safety in the operation.

Indications for Operation.—Intrathoracic projectiles should be removed when the patient complains of pleurodynia, shortness of breath on slight exertion, cough or dyspnœa, more or less frequent hæmoptysis, and when there are signs of congestion in the lung surrounding the projectile, with slight elevations of temperature. When no symptoms referable to the projectile exist, the question of its removal should be considered with reference to the possibility of its causing future trouble. Also, "éclats" should always be removed from a military patient, where their presence prevents him from re-entering Class A. When the projectile lies in the mediastinum or hilum of the lung, its size and the degree of tolerance must be carefully balanced with the danger of its removal. In the average case the intervention is so simple, the extraction so easy, the recovery so prompt, and the risk so small, that due weight must be given to these things when the subject of operation is under discussion.

CONCLUSION

1. This method is by far the easiest and most rapid way of extracting a foreign body from the lungs.
2. It is the most certain and direct way of reaching the projectile.
3. It is free from operative shock.
4. It traumatizes the least possible amount of tissue.
5. It reduces post-operative sequelæ to a minimum.
6. The recovery is rapid and the mortality low.

It will not demonstrate fragments of clothing which may have been carried in with the projectile.

Extractions of foreign bodies from the lung should not be attempted by the surgeon until he has served an apprenticeship with an expert radiographer, has acquired the necessary dexterity of hand, and has learned to correlate intuitively the shadows of the projectile and tip of the forceps.

THORACIC FISTULA AND CHRONIC EMPYEMA *

A NON-DEFORMING OPERATION FOR ITS CURE

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CHEST-COLLAPSING operations for the cure of sinuses following empyema are, except in rare instances, unjustifiable and unsurgical. Not only are they followed by permanent thoracic asymmetry with its train of compensatory pathology but the function of a large part of the breathing area of the lungs is practically destroyed. By these operations the attempt is made to bring the mountain to Mohammed—the immobile to the mobile—in a panicky effort to obliterate the pneumothorax at any cost.

The method here to be described will restore the lost pulmonary function and close the thoracic fistula without seriously reducing the capacity of the diseased side. Its danger in my hands has been far less than that of the Estlander, Schede, Wilms or Delorme operations and it needs but a single demonstration to convince one of its many advantages. It is not a "one-man" operation, nor is there required special skill in carrying out its technic, though a single practical demonstration is preferable to the most painstaking paper description.

THE OPERATION

1. *Anæsthesia*.—The intrapharyngeal method, while not indispensable, is of such value and is so simple that its adoption in these cases is advised. If ether is used it should be contained in a suitable bottle with two short tubes in a perforated stopper.¹ Neither tube should extend below the surface of the liquid. A dental foot bellows, or, lacking this, a paquelin bulb, will furnish the air current, a second tube of about fourteen French calibre leading from the bottle to the patient. Three and one-half inches from the end of this second or breathing tube there should be a mark and the tube should be inserted into one nostril not farther than this. If the nitrous oxide and oxygen mixture is used the bellows will not be needed, the force of the current being regulated by means of the cock, the gas passing through the wash bottle. The patient is first put to sleep in the usual way and the intrapharyngeal differential pressure is supplied only when it is called for by the operator. I am speaking here of the chronic empyema in which old adhesions have steadied the mediastinum so there is no to-and-fro flapping, with the attendant cardiac and respiratory dangers. (In recent wounds of the thorax when no lymph desposit has formed

* Read before the American Surgical Association, June 16, 1919.

¹ An excellent stopper with cock arranged so as to switch to ether or air has been devised by Dr. Wm. Branower, of New York.

it is necessary to employ intrapharyngeal pressure throughout the operation.²)

Position.—The patient is placed over a pillow and on his sound side in a scoliotic posture, the intrapharyngeal positive pressure aiding respiration should there be embarrassment. The hips and knees are flexed, a pillow is placed between the knees and a strap from under the table maintains the attitude, the patient being further steadied by sand pillows at each side.

The incision is in the seventh or sixth interspace and by preference should not enter the old drainage wound. It begins behind the costal angle and extends almost or quite to the cartilage. Part of the latissimus dorsi must be divided and it is well to cut between ligatures the vessels which traverse it. A part of the serratus magnus is treated in the same way. The subscapular and the long thoracic vessels are now easily seen and tied before they are cut and the hemorrhage thus controlled is insignificant.

Entering the Thoracic Cavity.—The knife now divides the intercostal structures at the middle of the wound by an incision about two inches in length close to the upper border of the lower rib, taking care not to injure possibly adherent lung. This incision is now lengthened forward and backward with stout scissors until a sufficient opening has been made to separate the ribs by blunt traction, exposing enough of the interior to work safely and keep clear of the lung. The opening is then further enlarged until it is the full length of the cutaneous wound, when a powerful rib retractor—De Quervain's or the writer's—is placed in position and the ribs separated gradually as far as seems safe, usually about three inches. It is possible that the intercostal artery may now be wounded behind the costal angle, but through this large incision the vessel is easy to secure.

In these old empyema cases the chest wall is firmly fixed by fibrous tissue, so that it is necessary to divide from one to three ribs upward or, sometimes, downward, at the posterior angle of the wound; or, very rarely, upward at its anterior end, in order to expose every recess of the cavity, the skin incision being continued upward or downward from the posterior or anterior angle. The blades of the retractor can now be separated six inches or more. A second rib spreader may even be placed in the vertical part of the wound, further enlarging the exposure. In dividing these ribs it is well to use a Liston's forceps, cutting *slowly* through the periosteum and soft tissues at one stroke. The blades of the forceps are closed upon the edges of the rib, not upon its surface (Fig. 1). The vessels rarely bleed and often are not divided, though the bone is cut by the crushing force employed. If necessary, however, they may be secured by a hæmostatic stitch and divided with scissors after the section of the bone. When ribs have been cut at the posterior angle of the wound, it has been my custom before closing the thorax to cut away about half or

² See note at end of paper.

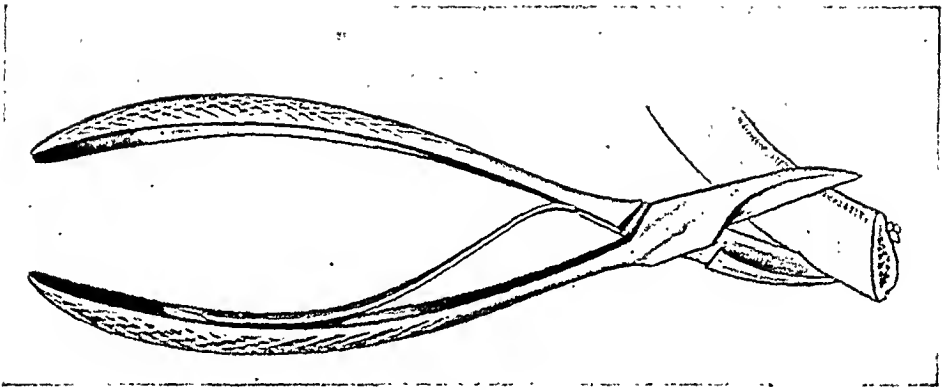


FIG. 1.—Method of dividing ribs together with periosteum and the structures of the costal groove. Note that the forceps is held so as to cut through the rib in its longest diameter.

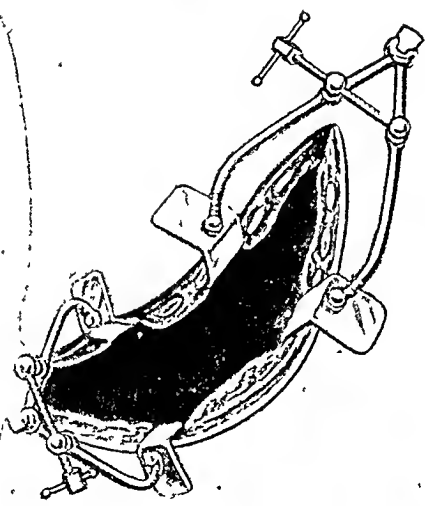


FIG. 2.—Diagrammatic representation of the incision seen from behind. Two rib-spreaders are being used. This is a convenience, not a necessity. One rib spreader is all that is actually needed.



FIG. 3.—Diagrammatic drawing of anterior part of wound. Rib-spreader in position.

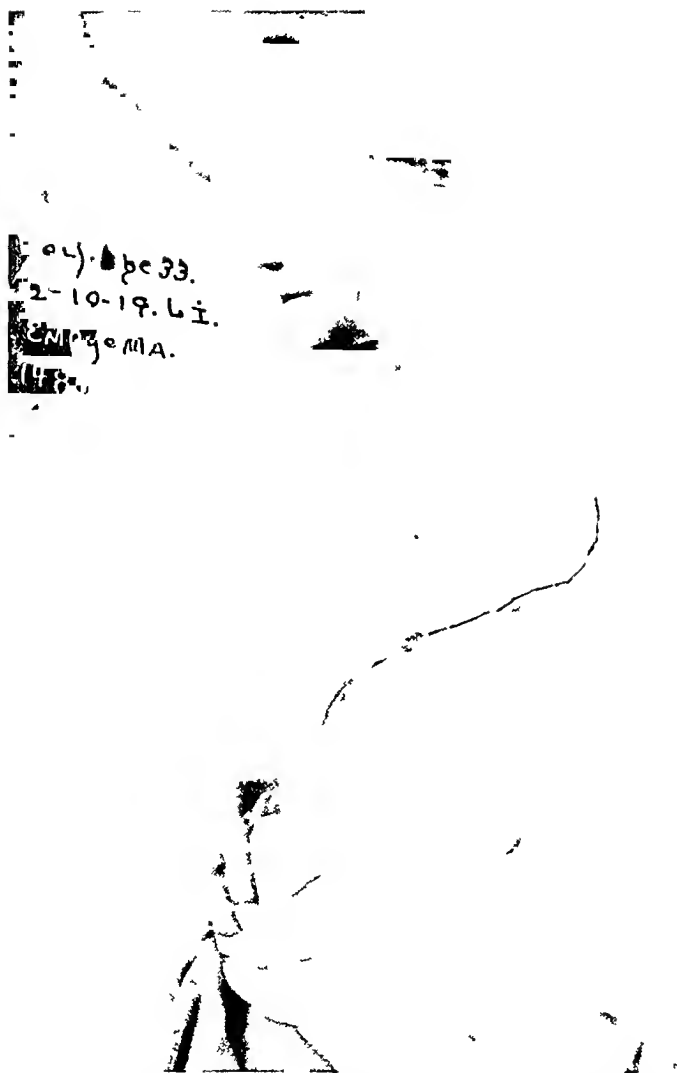


FIG 4 —Illustrating function of arm and shoulder four weeks after the operation. No counter opening was made in this case. The scar is so faint it was necessary to line it on the photograph.

three-quarters of an inch of the anterior portion of each rib beyond the place of its division so as to prevent post-operative pain and trauma by the grinding together of the cut ends.

Mobilization of the Lung.—With the rib retractor in position every part of the empyema cavity lies revealed before us. Often it will appear as if there were no lung in the chest, the entire organ being compressed into the angle between the ribs and the bodies of the vertebræ. All landmarks are usually found to be obliterated, and on wiping away the pus and loose tags of lymph the wall of the cavity is seen smooth, glistening and of a grayish color. With a scalpel an incision is now made into the visceral portion of this membrane from the apex to the base of the cavity, taking care not to wound the lung. This incision at once widens spontaneously and an attempt should be made to find the line of cleavage between the membrane and the pulmonary tissue, dissecting bluntly with instruments or finger. Second incisions at right angles to the longitudinal one will permit further expansion and the loose tags of membrane may be cut away. The anæsthetist now insufflates the lung by closing the free nostril and holding the patient's lips together while the air or ether vapor is forced through the intranasal portion of the tube. If this tube is not more than three and a half inches long air will not enter the œsophagus and the lung will expand, almost or quite filling the chest cavity. Fine bubbling upon its surface is no cause for alarm but a distinct hissing sound means that a bronchial branch has been opened, an accident which in very old cases cannot always be avoided. These fine bronchial openings may lengthen the time of healing, but in my experience they have always closed without further operation. The lung, even though it has been confined for months, will nearly always yield to this treatment, but it occasionally happens that fibrous processes extend down into the pulmonary tissues so that it is impossible to peel away the membrane. Cross hatching by multiple incisions down to the lung as described by Ransohoff should then be made and sufficient expansion can usually be secured. All parts of the cavity, especially the part near the apex, should be carefully inspected and secondary pockets smoothed out into the main chamber. The adhesion of the lower lobe to the diaphragm must be treated with great care, the attenuated flat pulmonary flap being often mistaken for the diaphragm or, still worse, *vice versa*. As a rule, it is unnecessary to peel any part of the lung from the chest wall and it is unwise because of possible hemorrhage and also because the denuded part of the parietes is much more prone to infection than is the lung itself. When it is evident that no further expansion can be secured the tract of the original thoracotomy wound is well curetted and a tube is drawn through from within outward by a dressing forceps. This tube should have two perforations near its inner extremity and should extend only a short distance into the thorax. The large wound is now closed in three layers, using chromicized catgut interrupted sutures for the muscles, and silk

or silkworm gut for the skin. No pericostal or percostal sutures are desirable. The ribs in these old cases do not at once fully approximate, but in drawing together the muscles an interspace of about one and one-half inches is left, and through this opening the outer wound drains into the thorax and thence out by the tube, the cutaneous wound closing by a linear scar.

When the patient leaves the table the lung will again have partially collapsed and during the after-treatment the patient must aid expansion by repeated blowing exercises. I have found that an ordinary rubber cushion or pillow with a tube attached to its valve opening makes an excellent apparatus for this purpose. A ligature tied around the tube to stricture it forms a good resistance. The presence of a bronchial fistula greatly impedes progress, but, unless it is very large it need not cause failure. In such cases Beck's paste or a 10 per cent. bismuth vaseline ointment may be injected when the wound has healed down to a sinus. Prompt closure is the rule.

After-treatment.—Shock is rare after this operation and ordinarily the blowing exercises may be started within the first twenty-four hours. And after three days the cavity may be cautiously treated by the Carrel-Dakin method, injecting not more than one-half ounce of the fluid every two hours, night and day. The first sign of coughing or bronchial irritation must be the signal for the instant discontinuance of the injection, for this means that the fluid or its liberated chlorine has entered some minute and unsuspected bronchial opening. It is necessary, too, that there should be a free opening for reflux. Five or six days after the operation, vertical fluoroscopy should be performed and notes taken on the mobility of the lung when the patient coughs or strains. The discharge will gradually diminish and in five to seven days the tube may be left out. The usual time of healing is about four weeks from the day of operation. Occasionally the drainage opening will close without the complete obliteration of the cavity, as is sometimes the case when acute empyema is treated by Carrel-Dakin disinfection, and, rarely, the fistula will reopen, only to close again in a few days. The severed rhomboids and the other muscles quickly and firmly unite, so that the writer has seen no permanent impairment of arm or shoulder function (Fig. 4).

Selection of Cases Suitable for This Operation.—Patients with cavities and discharging sinuses persisting for more than two months after drainage for empyema and unsterilizable by the Carrel-Dakin method should be examined with the vertical fluoroscope. Those with large rigid cavities and profuse discharge are proper subjects for this operation, which may be described as Major Non-collapsing Thoracoplasty. Small cavities when resisting other treatment are also suitable for this form of thoracic surgery including the full exploration of the thorax in trauma, by careful two-hourly flushing with Dakin's solution for five or six days before operating, but never should this cavity be filled—much less dis-

tended—by the antiseptic liquid. A fine tube should be employed with free space alongside, or an additional short tube should be inserted to prevent retention. The main tube may be as long as the cavity and open at the end, without lateral fenestræ. Inject slowly and always be on the lookout for symptoms of "gassing."

NOTE.—I am aware that some surgeons do not consider differential pressure a necessity in thoracic surgery. And in operating upon certain war wounds in which constant traction is made upon the lung by the operator, the mediastinum is steadied so that ordinary exploration and the removal of foreign bodies can be safely accomplished.

In old infected conditions also the positive pressure is hardly necessary except to test the pulmonary expansion; but in all other forms of thoracic surgery including the full exploration of the thorax in trauma, in resection of lobes and in operations upon the œsophagus or other intrathoracic organs, the writer is convinced that the omission of some form of differential pressure will greatly jeopardize the patient.

APPENDIX: EXTRACT OF MILITARY REPORT

Authority to publish granted
Board of Publication, S.G.O.
(Signed) Loy McAfee, Sec., M.R.
Date 6/23/19

From: Lieut.-Colonel Howard Lilienthal, M. C., N. A.

To: The Chief Surgeon, American E. F.

(Thru Director of Professional Services)

Subject: Report on Empyema at Base Hospital No. 101.

1. Arrived at Base Hospital No. 101, on Par. 1, Hospital Order No. 153, B. H. No. 3, July 9, 1918.

2. First examination of patients July 10, 1918. There was an "Empyema Ward" with 31 patients all having thoracic sinuses following rib resection and drainage for empyema. These were the patients remaining from a total of 44 nontuberculous cases operated upon in this hospital, or 70 per cent. not well after from six weeks to six months following operation.

At the time of this writing, thirty-six days after my arrival, there are only three of these cases with unhealed wounds.

Ten cases showed pyopneumothorax with sinuses, most of them with copious purulent discharge. These were selected for the thoracoplastic noncollapsing operation (Lilienthal). I demonstrated this method in three cases, the other seven being operated upon under my supervision by Captain (now Lt.-Colonel) James A. Duff, M.R.C., Chief of the Surgical Service. One of the first three patients died—the only one among those operated upon by major thoracoplasty. Six patients are healed, one only three weeks after operation. The others are convalescent with excellent prognoses except one bedridden since his first operation, two and one-half months ago, and not yet out of danger.

Twenty cases with simple sinuses and pneumothorax were treated by disinfecting the cavities, and the wounds soon closed spontaneously.

One large bronchial fistula closed after the injection of bismuth paste for X-ray diagnosis.

3. There was blue pus in every wound in this ward, probably carried by the numerous flies, a nuisance, which, in the absence of screens and because of the proximity of filthy civilian conditions it is difficult or impossible to abate. The pyocyaneus disappeared under daily applications of iodine to the wound and Dakin's solution to the surrounding skin. Even in the presence of infection from within the chest there were but two cases in which the external operative wound had to be drained because of infection, primary union being the rule.

In addition to these ten cases, I have had ten others and three which are still under observation.

One of the latter had been operated upon three times before my own operation which was done on April 21, 1919, just two months before the present note. It was a residual empyema of the mediastinal portion of the pleura in a boy of sixteen. Bronchial fistula was present, greatly impeding the after-treatment. The cavity is diminishing in size, the temperature is on a low plane, although not yet continuously normal, and it is believed the patient will recover.

Two patients died. One, a boy four years old, after nine months' illness. He was operated upon on November 15, 1915, and died within forty-eight hours. Perhaps if the work had been done in two stages he might have recovered. It was a case of staphylococcus aureus sepsis. The other death was that of a man forty-three years old, with a left upper lobe chronic bronchiectetic abscess and secondary empyema. He died a little more than a month after the operation, December 4, 1914, of sepsis.

To sum up it may be stated that the procedure here described should be selected in the cases in which it has been heretofore customary to perform major chest collapsing operations or the Delorme-Fowler decortication.

There are no cases of tuberculosis in this list.

EMPHYEMA *

By JOHN STEWART RODMAN, M.D.
OF PHILADELPHIA

RECENTLY MAJOR M. C., U. S. ARMY, CHIEF OF SURGICAL SERVICE, BASE HOSPITAL, CAMP BOWIE, FORT WORTH, TEXAS

THE basis of this report is founded on the author's experience during service in the Army, first, at the Base Hospital, Camp Bowie, Fort Worth, Texas, from September 15, 1917, to April 1, 1918, and General Hospital No. 14, Fort Oglethorpe, Ga., June 5 to October 10, 1918. During this time approximately 240 cases of empyema came under observation in which I either personally was responsible for the surgical management or supervised it.

In passing, a word might be said as to the arrangement for the management of infected cases in general at these two hospitals. Owing to the pavilion system of building these structures and to a comparatively large staff assigned to the surgical service it was possible to entirely separate the infected from the clean cases. Especially was this management entirely satisfactory at Camp Bowie where a separate set of wards, all on one row, a separate operating staff and operating room were used. A surgeon of experience was put in charge of this group of cases and under him a first assistant and eight ward surgeons, two for each ward set aside for this purpose. This staff gave their entire time and undivided attention to this part of the work. A separate operating room personnel worked with this part of the staff. It was my good fortune while in charge of the Surgical Staff at the Base Hospital, Camp Bowie, to have had Capt. L. H. McKinney, of Colorado Springs, assigned in charge of these cases. He personally performed one hundred and six thoracotomies for empyema before being called elsewhere for duty.

Upon entering the Army the author, with most others, held to the opinion that empyema called for immediate operation. This opinion was based on experience in civil practice with pneumococcus empyema and the experience gained in the Army has in no way changed this feeling. However, we were to deal with a very different type of infection, one that demanded a different plan of treatment and in which, no matter what plan was followed, a much greater mortality resulted. I refer to the empyema caused by the streptococcus hæmolyticus following in the wake of a violent epidemic of measles complicated by bronchopneumonia.

Before going into the surgical management of this extremely interesting type of empyema as it developed in our hands, it will be well to mention several of the other features shown by these cases. It was our melancholy distinction to be stationed at the next to the worst camp in the country from the standpoint of virulence of this epidemic. I refer, of course, to the epidemic of 1917 and 1918, during which in a little more than

* Read before the Philadelphia Academy of Surgery, March 13, 1919.

the three months of November, December and January, one-third of the command of the 36th Division, some 8000 troops, suffered from measles. It was a most pernicious type of measles in that the complications of bronchopneumonia leading to empyema, mastoids and other metastatic infections were common. While it is not our province to go into the epidemiology of this epidemic, a reasonable explanation of the severity of the infection at Camp Bowie may be offered in the fact that the troops encamped there were the Texas and Oklahoma National Guard, made up entirely of men from rural districts, for the most part non-immunes to the respiratory infections.

The pathology of this type of pneumonia was interesting and unlike that of the more familiar type caused by the pneumococcus. Pleural exudates were the rule and formed quickly in the course of the disease. In fact, it was not an uncommon occurrence to find that on the third or fourth day of the disease a sufficiently large pleural exudate was present to greatly embarrass respiration. At this time, of course, the pneumonic process was still in full bloom and the fluid while flaky was clear enough not to be called macroscopic pus but smears and cultures always showed the streptococcus hæmolyticus. The character of the fluid and the fact that the pneumonic process was still active played an important part in the development of the plan of treatment which gave the best results as we shall later show.

The diagnosis was interesting and taxed the watchfulness of the medical side of the hospital. X-ray proved of great value in localizing early collections and those that became "walled off" later on. It was interesting to learn by this means that most of these collections of fluid started to form in the interlobar fissure, and it was a distinct help to the operator to see the chest cavity through the fluoroscope and to mark the chest with blue pencil at the point where the fluid was most apt to be adequately drained.

It was during the early part of November, 1917, that the surgical service began to be called in to deal with empyema. Having, as mentioned before, the strong conviction that even microscopic pus in the chest cavity must be evacuated as soon as possible, especially where respiration was markedly embarrassed, the first fifty cases were treated according to this plan. Many of this group were all but moribund when first seen with a view to surgical interference. In fact, some were actually moribund and nothing could be done. This state of affairs was not due to any laxity on the part of the medical staff most ably conducted by Major J. G. Greenway, but to the severity of the infection and the astonishing rapidity of the disease process. In this first group of fifty cases the plan was followed of draining the chest cavity as quickly and in as simple a way as possible. Accordingly, thoracotomy, without rib resection, was done for the most part under local anæsthesia and drainage provided for with one rubber tube of large dimension. Often this was

done in the ward, as it was not thought wise to attempt moving the patient to the operating room. The mortality in this first group was high and not a few died within several hours of the thoracotomy, enough, in fact, to lead us to believe that this plan of treatment, while apparently based on sound surgical principles and civil experience, was not the one best calculated to deal with this particular type of empyema. Of the fifty cases twenty-three died, a mortality of 45 per cent. Such a mortality was alarming and had we not by then begun to hear of even larger percentages being lost in other base hospitals the prospect would have been most discouraging. The explanation for this high mortality may have been in the several factors mentioned by the Empyema Commission at Camp Lee—the opening of raw surfaces with a consequent blood stream infection or relief of compression of the laboring lung. To me the latter seems most plausible since we now believe that there was a physiological reason for the exudate being present—namely, to splint the infected lung.

It is an interesting fact that quite independently of each other and at about the same time some of those responsible for the treatment of empyema at the base hospitals in the army, changed materially the plan of surgical management. Since even thoracotomy without rib resection under local anæsthesia for some reason often added more to the load that these patients were carrying instead of relieving it, there was only one other procedure simpler still, namely, aspiration. Accordingly, after the first fifty cases we decided to aspirate the worst cases and found to our great relief that this procedure was a distinct advance in treatment. As the fluid was thin at first it was possible after diagnostic puncture had been done to aspirate away by means of the Potain aspirator the greater part of the fluid. The improvement in the general condition, as a rule, was marked, the patients appearing less toxic and respiration became easier. Of course, the chest cavity would soon fill up again and aspiration had to be repeated usually after the lapse of three or four days. However, after the second or third aspiration the general condition of the patient had substantially improved and the fluid taken on the character of frank pus. As we then began to be troubled with reaccumulations of fluid in those in whom early intercostal thoracotomy had been done, owing, we believed, to inadequate drainage, thoracotomy with the resection of one rib as low down as possible, usually in the eighth posterior axillary line, became the operation of choice. The patients also after several aspirations were in much better condition to withstand the shock of this more formidable procedure. The surgical treatment of choice then became aspiration, late operation, and thoracotomy with rib resection. To this we added irrigation after one week had elapsed with normal salt solution and later Dakin's solution. I must confess to having had a prejudice at that time of irrigating an acute empyema cavity which I have entirely lost since.

As a result of this plan of treatment the mortality dropped about half so that in our first hundred cases the mortality, all told, was about 28 per cent., still very high as compared to that experienced in handling pneumococcus empyema.

The plan of aspiration and late operation with rib resection was firmly established with us after trial in our second fifty cases and was not changed in the second hundred. To this plan, however, was added routine irrigation with Dakin's solution every three hours through the permanent drainage tubes, as irrigation with salt solution seemed to add little or nothing to speeding the convalescence. The chest cavity was filled with Dakin's solution and the patient turned on his side for a few minutes and then the fluid allowed to run out. This was a distinct advance in that the character of the discharge changed, lost its purulent nature and assumed more of a viscid appearance. The toxæmia also seemed to more rapidly disappear. Even with the irrigation added our great problem became not so much the mortality as the morbidity. Accordingly, these patients were given open air treatment even more than formerly, and setting up exercises carefully conducted by a medical officer were added as soon as convalescence was established. Such exercises were a material help in shortening convalescence and in leaving expanding lungs, instead of the rigid fixed ones as was the rule before such systematic exercises were established. I now believe that irrigation with Dakin's solution also had a good deal to do with dissolving fibrin and hence preventing adhesions. To recapitulate, then, the plan of aspiration, late operation, rib resection, usually under light chloroform anæsthesia, irrigation with Dakin's solution, and setting up exercises was followed in 133 cases. The mortality had again dropped, it was about 10 per cent. for this group—a vast improvement over 45 per cent. for the first fifty and 28 per cent. for the first hundred. The average period of convalescence was five to six weeks in this series of 133 cases, but some of the early cases despite secondary rib resections persisted in drainage for two or three months. In all there had been some 233 cases operated on by the surgical service of the Base Hospital of Camp Bowie during the writer's service.

In the spring of 1918 it was my good fortune to take the course of instruction in the treatment of infected wounds at the Rockefeller War Demonstration Hospital, New York. I was much impressed by the technic used there and the results obtained in treating empyema. Their mortality was still too high, some 24 per cent. in a comparatively small group of cases, but the morbidity record was much in advance of any I had seen. I believe that the high mortality was not due to the technic used but to the fact that aspiration was not practiced and all cases operated at once.

The technic developed there is briefly as follows: Wide resection, two to three inches of the eighth or ninth rib in the posterior axillary

line, introduction of four Carrel tubes, two upward and two downward, each tube having twenty perforations, immediate irrigation with .5 per cent. Dakin's solution (full strength) on the table, leaving the wound wide open and packing with gauze soaked in Dakin's solution tight enough to steady the tubes and protecting the surrounding skin with sterilized vaseline. A rather voluminous dressing is then placed over the wound and the patient returned to bed. Instillation of 100 c.c. Dakin's solution every two hours by the nurse and irrigation daily at the dressing complete the procedure. The results of this treatment were striking, the toxæmia almost immediately disappeared, the character of the discharge became less purulent almost from the start. The Dakin's solution dissolved out the large fibrin masses and the wound could usually be closed after such chemical sterilization in from ten days to three weeks. A normally expanding lung remained and the soldier returned to full duty. The marked shortening of the convalescence and the early return to duty was certainly worth the extra trouble which this technic entails. After leaving the Rockefeller Institute the writer was assigned to temporary duty at General Hospital No. 14, Fort Oglethorpe, June 5. The epidemic of pneumonia was over at that time, but during the summer I had the opportunity to try out this technic in eight cases of streptococcic empyema. Of these one died from an involvement of the other side, the other seven, however, making unusually rapid recoveries. In one it was possible to close the wound in eleven days, in another thirteen days, and the remainder averaged from two to three weeks.

The comparison between these cases and some that had been treated by simple intercostal thoracotomy was striking. Some of the latter had drained for months and were forever incapacitated for further army duty. Before closing the chest wound, in order to be well within safety, I made it a practice not only to have had a count of less than one bacterium to five fields, but also to secure negative culture. After this brief added experience I now believe that this technic, in conjunction with aspiration and late operation, is ideal in spite of reports of hemorrhage and bronchial fistula, mostly from the army overseas. Strangely enough, I have encountered these complications but once, and that in my last case, operated upon at the Presbyterian Hospital, since my discharge from the Army. This patient did develop a bronchial fistula because of which Dakin irrigations had to be stopped, and six days after discontinuing the Dakin's solution, had a rather severe hemorrhage from the lungs which was repeated several times. He made a satisfactory recovery, however, and I am loath to believe that the bronchial fistula and hemorrhage resulted from the Dakin's solution. These complications have not arisen in the series treated at the Rockefeller Hospital and they do occur, we know, in cases where Dakin's irrigations have not been used. Needless to say, if a bronchial fistula already exists the use of Dakin's solution in the chest cavity is contraindicated.

I have not used any of the methods of suction advocated nor made any attempt at preventing pneumothorax, as neither has seemed necessary. Negative pressure as suggested and tried with success by the Empyema Commission, at Camp Lee, may be the final word in the treatment of these cases. It is difficult to see how an improvement can be made, however, in the plan of aspiration, late operation, wide resection, Carrel-Dakin irrigation and secondary closure of the wound.

Before closing it might be well to mention some of the interesting complications encountered in this series of empyema. General blood stream infections were not uncommon and metastatic abscesses were frequently seen. Next to the pleural cavity the place of choice for infection seemed to be the mastoid cells and there were considerably over 100 of such cases operated at the Base Hospital, Camp Bowie, during the epidemic. An interesting metastatic involvement was a suprapubic abscess deep in the abdominal wall. The first case of this sort appeared to have a distended bladder when the tumor was first discovered as there were none of the usual signs of abscess present. Catheter failed to recover more than a negligible quantity of urine, however, and exploratory needle puncture revealed streptococcic pus. Joint involvement was not uncommon and other superficial abscesses were frequently encountered. Post-mortem commonly revealed pericardial involvement.

Altogether we were distinctly impressed with the virulence of the streptococcus hæmolyticus and with its pus producing ability.

THE TREATMENT OF EMPYEMA *

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THE purpose of this brief communication is not to present any original ideas concerning the treatment of empyema, but rather to call attention to the pathology of the disease, and consider in how far the various methods in vogue are sound in conception and technic.

The name "Empyema" is, in itself, lacking in clearness. In current usage it is sufficiently ill-defined to be a source of confusion in discussing treatment. It is not unusual to find such a discussion involving several quite different pathological processes, and any attempt to unify treatment is obviously futile.

Empyema should be used to indicate a purulent exudate within the general pleural space, limited only by the extent of the infective process. Local collections of pus, walled off by adhesions, are intrapleural abscesses or interlobar abscesses, and have no place in this discussion. A communication with the bronchial tubes is a complication of the condition under discussion. An abscess within the lung tissue is another complication. The presence of these complications may not materially alter the treatment needed for the empyema, but it is more than apt to do so, and success or failure of the treatment may in no way depend upon the pathology of the empyema itself.

Again, in considering empyema proper, one is required to differentiate between many important factors. The infecting organism is a matter of the greatest import. One would hardly include in the same category a peritonitis due to a perforated gastric ulcer, an acute gangrenous appendicitis and the migration of the gonococcus through the Fallopian tubes. There are quite as distinct differences between an empyema of streptococcus hæmolyticus and pneumococcus origin as between the peritonities named. Again, the path by which the infection gains entrance into the pleural space plays an important part. It may be by a direct extension of the pulmonic infection breaking in miliary fashion through the visceral pleura; it may be by way of the lymphatics, either in the form of actively growing thrombi in the vessels, or possibly by the organisms following the lymph current, though normally this is probably away from the pleural surface; or it may be simply an expression of a general blood invasion, with the empyema only one manifestation of its extensive outbreak.

Until discussions on treatment narrow themselves to one or another of

* Read before the American Association for Thoracic Surgery, June 9, 1919.

these numerous pathological entities, confusion is bound to be supreme, and routine surgery only chance bungling.

During the past two years empyema has forced attention from a large number of physicians and surgeons who, heretofore, only took a passing interest in it. Its prevalence has been rather in excess of any surgical condition we have been called upon to treat. It has been, to a large extent, secondary to pneumonic processes associated with the influenza pandemic. A majority of these lung infections have been caused by, or associated with, the streptococcus hæmolyticus, which, in ordinary times, is not a prevalent factor. Very much of the discussion concerning empyema has originated with those who have had no extended experience with the disease in former times, and their views have been formulated on but one phase of the subject, without a full comprehension of the diversity of its pathology.

As demonstrated by McCallum,¹ this streptococcus almost invariably invades the pleural surface. Early in the disease, when terminating fatally, there is not only an infected exudate in the pleural cavity, but the visceral surface is covered with velvety granulation tissue. The pleura itself is thickened with œdema and other inflammatory products, and in many instances adhesions between the two surfaces are found. In some instances, as determined by the clinical course, this invasion of the pleura subsides with the pneumonic process, but in others it persists as an empyema after the lung condition is healed. The pathological process when the various types of pneumococcus unassociated with the influenza disease are the infective organisms is quite different from the above. The pleura is much less frequently involved, and when it is, the pleuritis is more nearly a sequella; that is, it begins when the pneumonia is subsiding. The thickening of the pleura at autopsy is found to be much less than in streptococcal infection. This finding, however, is not indicative of the condition when a well-established pneumococcus empyema is present. In fatal pneumococcus pneumonia, death occurs before this stage is reached, and therefore autopsies on such cases show only the pleural lesion of the pneumonia, and not the empyema. If such cases survive the pneumonia, and later die from an empyema, either with or without operation, the pleural membranes show a much more marked thickening. This is also usually present when operation is undertaken comparatively early.

In essence, therefore, empyema in its simplest uncomplicated form is a purulent inflammatory process going on in a closed serous cavity. Under these conditions pus is formed under pressure, and since the thorax is comparatively rigid, there results a compression of its contents. The most easily compressible structure is the lung itself, and this organ loses a part of its air content. At the same time, its delicate serous covering becomes a more or less rigid barrier and offers resistance to the compressing process. This results in forcing over to the other side the mediastrium and the heart, and in many instances depresses the diaphragm. This is the extent of the process

¹ Rockefeller Institute for Medical Research No. 10, April 16, 1919.

in the majority of the cases that occur as sequella to lobar pneumonia under its ordinary occurrence in non-epidemic form. This is the disease for which through many years there has gradually developed an almost standard treatment which has proved most satisfactory and successful in cases not too long neglected.

The treatment was formulated to meet a definite pathological condition. It aimed, first, to establish ample drainage of the large infected cavity, with full knowledge that the infecting organisms would rapidly die out. Secondly, it aimed to obliterate the cavity which had resulted by reason of the compression and misplacement of the thoracic organs. As an adjuvant to these two aims, irrigation has from time to time been in vogue, but by most surgeons discarded. There has also been substituted for an ample drainage opening various types of intermittent or continuous suction, with the hope that the negative pressure thus established would tend to draw out the compressed lung, and thus hasten the cavity obliteration. This negative pressure has been obtained by elaborate apparatus consisting of a canula or tube inserted into the thorax so snugly that no air leakage could occur around it, and a pump or syphon suction. It has had a very thorough trial by many competent men, and has met with some success. More often than not, however, it failed to accomplish the desired end, either because the connection through the chest wall did not remain air-tight, or drainage was incomplete. In part its use is based on a misconception. The belief has been more or less prevalent that when an open thorax is present, the lung, unless adherent, completely collapses because of the tension of its elastic fibres unopposed by a negative pressure around it. This only occurs when the pleural cavity of the lung is not changed by inflammatory exudate, and the opening in the chest is so large that the inflow of air through it in inspiration is equal to that going through the glottis. Graham and Bell² have proved this experimentally, and have demonstrated that an opening 2 inches by 4.1 inches can be borne without complete collapse of the lung.

This means that with any smaller opening, each inspiratory effort tends to produce a negative pressure, and by just so much tends to draw air through the trachea into the lung on the affected side. Graham³ demonstrates that it goes in equal amount in each lung in the absence of inflammatory fixation of the mediastinum. Therefore, if ample drainage is provided through an opening not too large, and this opening is kept largely obstructed on its outer aspect by the application of copious dressings, ideal conditions are present to overcome the infection, and ultimately force the lung to reëxpand to its normal extent. The use of forced inspiration and expiration is a great aid to this process, and is habitually obtained with the blow-bottles. That a proteolytic agent like Dakin's solution intermittently diffused throughout the cavity is an aid is beyond question. It removes the substances on which bacteria live, and at the same time kills bacteria with which it comes in contact, and by just so much shortens the period of infec-

² Amer. Jour. Med. Scien., Dec., 1918, No. 6, vol. clvi, p. 839.

³ Loc. Cit.

tion. It also may aid in digestion of the inflammatory exudate on the pleura, and thus allow earlier lung expansion. Hence, the standard treatment of this disease, gradually evolved over many years, is seen to be based on a very sound reasoning, and succeeds because it accurately combats pathological conditions.

As encountered, however, during the past two years, the disease called empyema has differed from this simple form in many important particulars. It also has been treated by men who have never studied the underlying principles of this standard treatment, and consequently applied it to a very different condition, with inevitable but unexpected failure. To the initiated, the report of a commission was not needed to point out that a wide-open hole in the chest of a man desperately sick with a streptococcus toxæmia, was going to add to rather than diminish the cyanosis from which he suffered. The mechanical embarrassment under which his respiration labored could be as effectively relieved by a simple aspiration. So long as the fluid could be drawn through a needle, this relief could be afforded as often as was required. His toxic condition was also to a degree lessened by this procedure, but this was of minor importance, because the source of the absorbed poisons lay in the lungs, or other tissues, and not in the pleural effusion. Later, if his strength withstood the ordeal, and the purulent exudate continued in the pleural space, the standard operation was successfully performed. In many instances this was not needed, and the infected pleura returned to the normal with no other treatment than aspiration, either intermittent or continuous, sometimes aided by flushing with Dakin's solution through the aspiration apparatus. This was not only feasible, but successful, because of two factors. The fluid throughout the early stages is thin and relatively poor in coagulable substances. Therefore, the chest cavity can be completely emptied through a relatively small canula. The streptococcus hæmolyticus is not a deep invader. It lies close to the surface, and in many resistant individuals, though primarily very virulent, tends to die out. Hence, we repeatedly receive reports of such cases getting well. False inferences were drawn, and a widespread belief exists that the proper treatment of empyema lies in suction evacuation of pus and delayed or no operative treatment. Due consideration is also not given to the fact that no small number of these cases recovered when the exploring needle withdrew a cloudy infected fluid, and no operative treatment of any sort was employed.

It is not difficult to logically explain wherein the less radical forms of treatment fail to meet the requirements of the pathological conditions in a true purulent pleural effusion. In the first place, they do not satisfy the principle of adequate drainage of an active suppurative focus. This law can only be ignored with due caution. A suppurating surface as extensive as the pleura must be given constant and continuous opportunity to be freed from contact with the products of its lesion, if healing is to occur. If by chance—and I believe it is chance—the constant suction keeps the cavity empty, there is always a possibility that a latent infection will subsequently light up and the lesion occur. In the second place, all treatments of this

character are based upon the erroneous idea that the expansion of a lung whose thoracic wall is open cannot take place. Wherein this view is erroneous has already been explained, and as the suppuration grows less, and the drainage opening is permitted, day by day, to contract and is kept more continuously covered with a copious dressing, by a corresponding amount does the expanding force of respiration increase. There is thus an orderly return to the normal, the suppuration lessening as the lung, freed from its crippling thickened pleura, gradually expands, so that full expansion and a clean healthy pleura occur at the same time.

The expected time for the accomplishment of this is from four to five weeks. Any attempt to shorten it by chemical sterilization of the cavity and a tight secondary suture of the opening is doomed to such frequent failure that it cannot be recommended. The explanation is not difficult. Assuming that our bacteriological observation has covered every nook and corner of the infected portion of the pleura—an assumption that takes more credulity than I possess—a closure of the opening leaves a dead space within the thorax. The damaged lung does not immediately leap out to fill this, even under conditions of normal chest expansion. The almost invariable result is a serous effusion into this dead space which in itself prevents by that much the full expansion of the lung. The conditions are, therefore, ideal for a recurrence, namely, a pent-up collection of serum within a serous-lined cavity which recently has been the seat of a virulent infection. The fact that sometimes success is obtained and a final cure results in three or even two weeks does not alter the fact that it is obtained in spite of a violation of sound principles. The failures are more than enough to condemn the procedure, and when they do occur are more difficult to cope with than was the primary disease.

The purpose of the arguments herein presented is to call attention to the fact that if the experiences of the past two years are made the basis of the standard treatment of empyema, under conditions of pulmonary disease less abnormal than those existing during this trial, a distinct step backward will have been taken.

Reading of the history of empyema during the past five decades shows that from time to time there have arisen advocates of the so-called less radical forms of treatment, who have enjoyed a short period of success. Failure, however, always succeeded this period. Gradually, through the constant teaching of thinking masters, this disease has recently been handled along sound lines of therapeutic technic, founded on a full comprehension of its pathology. Any falling away from this will only result in a period of again learning old lessons with its resultant suffering.

Our argument may be summed up in the statement that no form of treatment for empyema which disregards the thorough drainage of the chest cavity by a rib resection, and the gradual reexpansion of the lung by respiratory effort, meets the requirements. Other means will cure a certain number of cases, particularly in such times as the disease occurs in abortive forms, which it has done during the past two years.

FOREIGN BODIES IN THE STOMACH *

BY RANDOLPH WINSLOW, M.D.

[OF BALTIMORE, MD.

THE presence of foreign bodies in the stomach, while always of interest, is by no means uncommon. They are found in three classes of persons: First, in those who swallow objects accidentally; second, in insane or otherwise unbalanced individuals, including those who swallow articles with suicidal intent; and third, in mountebanks or professional jugglers, who eat glass and swallow other dangerous objects as a means of a livelihood. The articles that are swallowed accidentally are usually single and smooth, blunt or rounded in character, such as coins, marbles and pebbles, which, if not too large to pass through the œsophagus, will usually also traverse the intestinal canal and be expelled per anum. But sharp-pointed and jagged objects are also swallowed accidentally, as pins, needles, hat pins, open safety pins, plates with artificial teeth and pieces of bone, which may become lodged in the œsophagus, or if they descend into the stomach, may perforate this organ, or if they pass into the intestine may lacerate or penetrate the walls of this tube. A case of this character came under my observation many years ago. A man while eating a chop swallowed the articular process of a vertebra. He was taken with violent pains and soon died. I was able to get an autopsy and found the bone far down in the small intestine, the mucous membrane having been extensively lacerated by a sharp spicule projecting from the bone.

An almost similar case with, however, a more favorable result, was reported by Weishart in the *Münch. Med. Wochenschrift*, vol. lxxiii, April, 1906: A woman, while eating, swallowed a piece of calf's rib from which a sharp point projected. This caused violent pains and collapse, but eventually the bone passed per rectum and she recovered.

It is really remarkable that so many sharp and pointed articles do pass through the alimentary canal without producing serious results, such as pins, open safety pins, knife blades, tacks and nails. In this connection the following case is of interest:

Swallowed a Nail.—B. J., boy, aged two and one-half years, on August 17, 1914, swallowed a wire nail. He was admitted to University Hospital in my service. An X-ray examination showed the nail lodged at the cardiac end of the stomach. He did not appear to be suffering in any manner from the nail, nor was there discomfort at any time during his stay in the hospital. On August 22, the nail passed per anum. No purgative was given at any time. Skiagraphs

* Read before the American Surgical Society, June 17, 1919.

were taken daily, which showed the nail passing slowly through the intestinal canal. The descent of the nail as shown by the daily skiagraph was not only very interesting but determined absolutely that no surgical interference was indicated.

Multiple objects are swallowed either by the insane or by mountebanks. The number and variety of articles ingested is great. Practically all of these individuals come to operation sooner or later. Sometimes several years may elapse without any serious symptoms being experienced, but in many cases the reverse of this is true. I desire to place on record here the history of a case of multiple foreign bodies removed by gastrotomy from an insane woman in August, 1918.

Stomach Filled with Pins, Safety Pins and Other Objects.—L. S. was admitted to University Hospital on August 15, 1918. The patient, a Russian Jewess, was admitted to the Springfield State Hospital for the Insane at Sykesville, Md., on November 8, 1916, with the diagnosis of dementia præcox. She is married and is the mother of three children. At the time of her admission to this hospital she had been ill for four months. There was nothing of especial interest in her case from a surgical standpoint until March 29, 1918, when it is recorded that she had nausea and vomiting with a little rise of temperature in the afternoon, but she did not appear to be in pain. She continued to eat well but a month later had to be fed through a tube. She has been losing weight.

May 30: "She has been sticking pins in her ears and vagina, which have to be removed frequently. She has also been found with hair pins and safety pins in her mouth, which are removed with difficulty. There has been some bleeding from the mouth, probably due to trauma from the foreign bodies."

August 8: "She has vomited a brownish material that looks like partially digested blood. She has the same material in the stools. She is kept in bed and is showing marked signs of weakness."

August 12: It is recorded that "There is a hard mass in the stomach, which crackles under the fingers. Vomiting is of daily occurrence, the vomitus consisting of the same dark brown material, which is still found in the stools."

August 15: She was sent to the University Hospital for operation. She is thirty-four years old, and is a thin, undersized woman weighing less than 100 pounds. She cannot, or will not, speak English and we can get no statement from her in regard to her condition. On inspecting her abdomen an elevation is seen in the epigastric region, and on palpating this a crackling sensation is felt. She does not appear to suffer pain to any extent. An X-ray examination shows the stomach to be filled with an immense number of pins, hair pins, safety pins and other objects, with ten pins and a hair pin in the intestinal canal. Her temperature was practically normal.

Operation was done on August 17, 1918, under ether anæsthesia.

A right rectus incision was made, the stomach exposed and lifted partially out of the wound and surrounded with gauze compresses. The stomach was distended and a vertical incision was made into it, in order to avoid the vessels. At first I attempted to pick out the foreign bodies with forceps, but as they were so matted together it was necessary to enlarge the incision and insert the whole hand in the cavity of the stomach in order to dislodge and remove them. This was a difficult and somewhat dangerous process, as there was great liability of lacerating my hand on these sharp pointed objects as well as of puncturing the walls of the stomach. However, I succeeded in removing them entirely. The stomach walls were much thickened and the mucous membrane was inflamed, ulcerated and covered with an exudate. There was quite free bleeding from the mucous membrane. The incision in the mucous membrane was closed with two rows of catgut sutures and the outer walls of the stomach with two rows of silk sutures. The abdominal wound was closed in tiers, without drainage. The patient stood operation well. When she was returned to her bed, Murphy's proctoclysis was instituted. Nothing was given by mouth for forty-eight hours, then coffee $\frac{3}{4}$ every two hours.

August 20: Milk $\frac{3}{4}$ and lime water $\frac{3}{4}$ every two hours.

August 21: Patient is in excellent condition; bowels moved several times. Proctoclysis discontinued and milk $\frac{5}{8}$ and lime water $\frac{3}{4}$ every two hours allowed.

August 22: Milk $\frac{3}{4}$ and lime water $\frac{3}{4}$ every two hours.

August 23: Continue milk and give one soft boiled egg.

August 24: Milk with two soft boiled eggs allowed.

August 25: Milk $\frac{5}{8}$ and lime water $\frac{3}{4}$ every three hours and one soft boiled egg three times a day.

August 26: Milk continued and four soft boiled eggs allowed. On this date four straight pins, one straight hair pin and one bent hair pin were passed per enema.

August 27: Milk $\frac{5}{8}$, lime water $\frac{3}{4}$ and five soft boiled eggs; slight suppuration in wound.

August 29: Six soft boiled eggs and milk as above. One straight pin passed per rectum.

September 1: Soft toast once a day is added to diet.

September 7: Soft diet. Patient has been sitting up for several days. X-ray shows a clump of three or four straight pins in lower bowel, but none in the stomach or in any other part of the intestinal tract.

September 10: Patient discharged to go back to the State Hospital. Subsequent to the operation her temperature was practically afebrile.

The following note was kindly furnished by the State Hospital as to the condition of the patient after her return to that institution:

October 14, 1918: "On September 10, the day she returned, her weight was 76 pounds; on October 12 it was 82 pounds. She is sleeping and eating well, is up and about the ward each day, and appears to be suffering in no respect from her unusual experience. She is kept

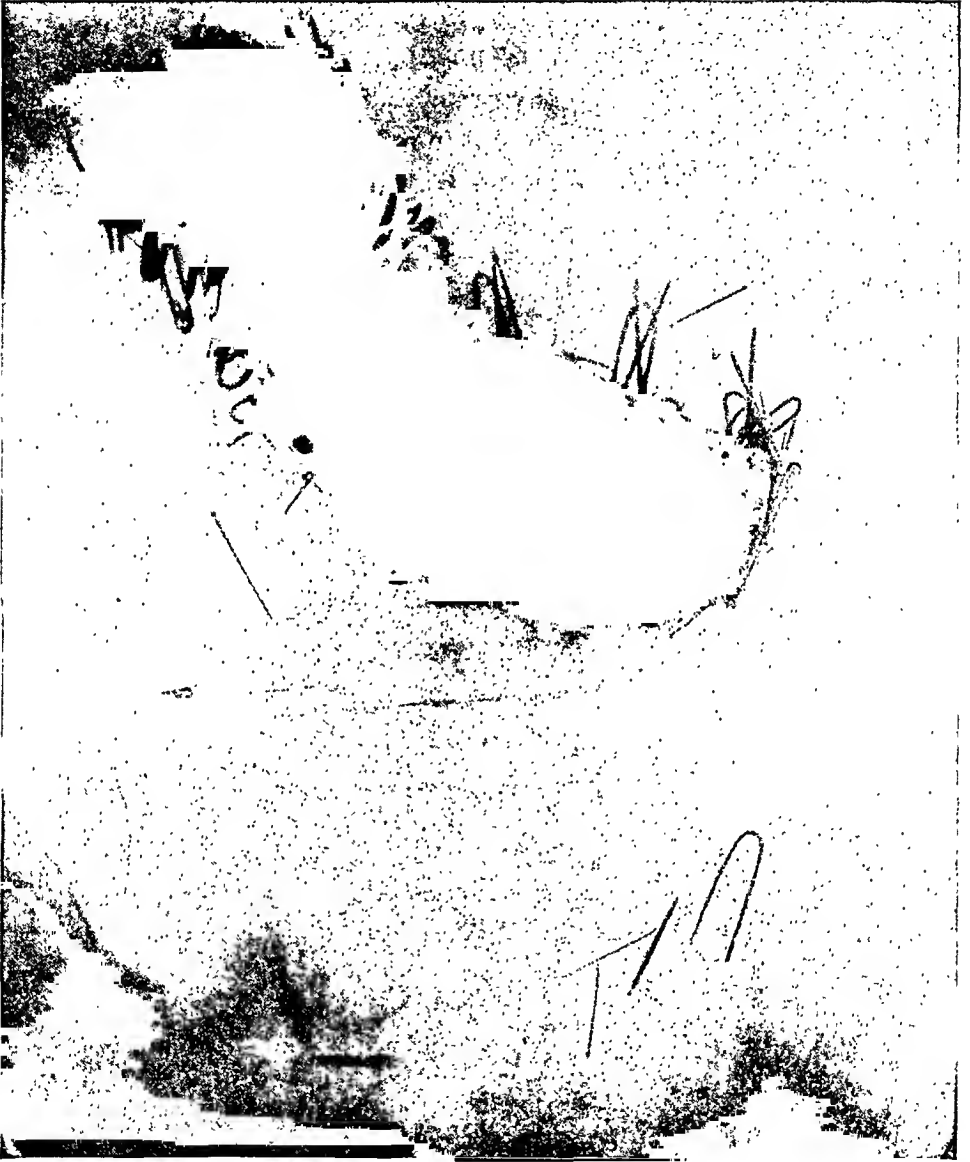
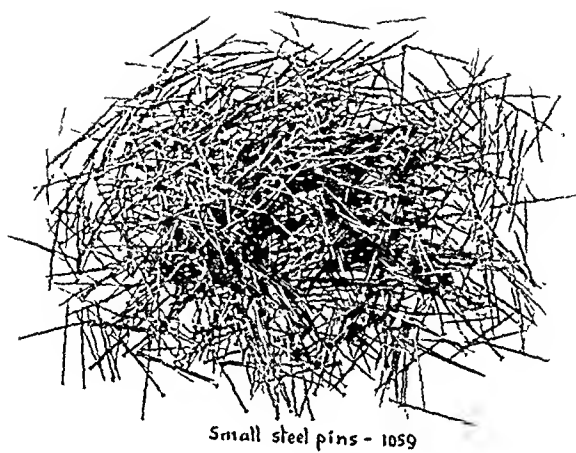
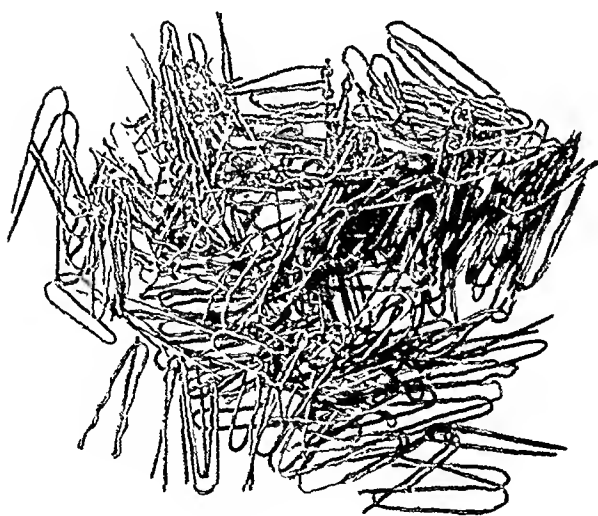


FIG. 1.—Roentgenogram showing foreign bodies in stomach of patient (L. S.) before operation.



Small steel pins - 1059



Hair pins - 129

FIG. 2.—Objects removed from the stomach of patient (L. S.), August 17, 1918, by Dr. R. Winslow. Photographed after removal.

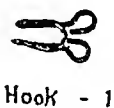
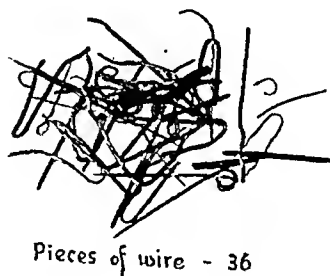
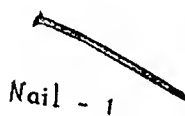
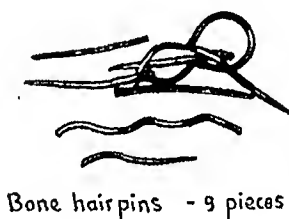
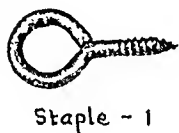
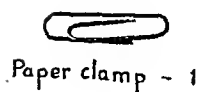
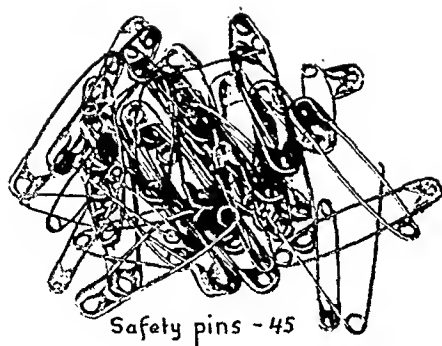


FIG. 3.—Objects removed from the stomach of patient (L. S.), August 17, 1918, by Dr. R. Winslow. Photographed after removal.

FOREIGN BODIES IN THE STOMACH

under close observation to prevent her from procuring her selected morsels. Mentally her condition is unchanged."

The foreign bodies removed from her stomach numbered 1290 different objects, as follows: Straight pins, 1059; safety pins, 45; hair pins, 129; pieces of bone hair pins, 9; pieces of wire, 36; buttons, 6; iron screw staple, 1; iron hook, 1; wire nail, 1; paper clamp, 1; garter buckle, 1; breast pin, 1. Besides these the skiagraph showed 10 pins and hair pins in the intestines, but at the time of her discharge all but three or four of these had passed naturally. The grand total of foreign bodies in her stomach and intestines on admission as shown by the X-ray and by removal was 1300, most of them sharp-pointed objects that were liable to perforate the walls of the viscera; that they did not do so is surprising. As to the length of time she had been indulging in this practice I am ignorant, but it must have taken a long time for her to secure so many articles, especially as she had been detained in a hospital for the insane, where she would have been under constant observation, a year and a half.

The interest in this case centres not so much in an operation of gastrotomy for the removal of foreign bodies as in the number and the dangerous character of the objects removed. As far as I am aware, this is the largest number of individual objects that has ever been removed from the stomach of the living human being, though Vandivert and Mills report the removal at autopsy of 1446 objects from the stomach of an insane mulatto woman. *Journal A. M. A.*, January 21, 1911, p. 180. There are, however, many remarkable cases of multiple foreign bodies removed by gastrotomy reported in the literature. I shall not attempt to make a statistical report of such cases, but will mention a few of the most remarkable examples.

MEISINBACH, St. Louis (*Jour. A. M. A.*, 1898, vol. xxx, p. 513), removed from the stomach of a mountebank 25 staples, 15 screws, 6 horseshoe nails, 30 wire nails, 19 cart-ridges and 2 broken knife blades which had been in the stomach nine years.

VON QUAST, Kansas City, Mo., removed from the stomach of a woman 9 ounces broken glass, 2 pocket knives, 1 barbed-wire staple, 5 knife blades, 3 screws, 1 horseshoe nail, 16 tacks and 9 nails. See article by Friedenwald and Rosenthal, *N. Y. Med. Jour.*, July 18, 1903.

HALSTED, Baltimore, from the stomach of a mountebank, 74 grams crushed glass and 208 other objects, including 21 pieces dog chain, 4 watch chains, 1 brass chain, 2 pieces of chain, 10 horseshoe nails, 54 wire nails, 35 ordinary nails, 8 screws, 2 screw-eyes, 7 knife blades, 1 knife handle, 50 tacks, 12 pins, and one piece of tin.—*Johns Hopkins Hospital Reports*, 1900, p. 1047.

INCH, Kalamazoo, Mich., 2 hat pins, 3 hair pins, 2 pieces wire, 1 button-hook minus handle, 1 screw head and 1 brass tack, and the patient subsequently passed handle of button-hook in 2 pieces, 2 carpet tacks, 3 pins, 1 screw, 4 nails and 1 piece wire.—*Jour. A. M. A.*, 1902, p. 603.

WARBASSE, New York, operated twice on a juggler, who was suffering from gastric tetany due to foreign bodies in the stomach, and on each occasion removed a large number of objects, such as nails, chains, etc.—*ANNALS OF SURGERY*, vol. xl, p. 909.

GAYLORD, Erie County Hospital, removed carpet tacks 453, penknife blades 41, screws 142, pen points 40, wire chain 3 inches long 1, and 6½ ounces ground glass, the whole weighing 2 pounds 3 ounces (l. c. Friedenwald and Rosenthal).

HEINZ MARKS, St. Louis, removed glass, tacks, nails, screws, etc., weighing 16 ounces (l. c. Friedenwald), *Medical Fortnightly*, St. Louis, May 15, 1892.

BALFOUR, Rochester, Minn., *Jour. A. M. A.*, vol. lxvi, p. 421, 1916, removed 7 teaspoons from the stomach of an insane woman.

AUTTEN, St. Louis, 2 gastroliths, weighing 517 grams (l. c. Friedenwald), *Medical Fortnightly*, August 14, 1894.

KORTMANN, 2 shellac stones, weighing 670 grams. This man worked in a porcelain factory and drank an alcoholic solution of shellac, which solidified in his stomach. They had been in the stomach 17 years (l. c. Friedenwald), *Deutsch med. Wochensch.*, 1897, E, No. 26.

Hairballs in the stomach form a large subject and are thoroughly considered by Rudolph Matas in an excellent article published in the *Transactions of the Southern Surgical and Gynecological Association*, 1915, p. 572.

While many single objects pass through the intestinal canal and are safely extruded, multiple foreign bodies usually lodge in the stomach and require to be removed by gastrotomy. At the present time an exact diagnosis is possible by means of the skiagraph and this method of examination will not be neglected by a careful surgeon. The removal of foreign bodies that have lodged in the stomach is a comparatively safe procedure and the percentage of recoveries is very high, even when they have remained in the viscera a long time. Naturally, the sooner they are removed the better the result is likely to be.

INGUINAL HERNIA*

AN OPERATIVE METHOD BY WHICH CLOSE TO 100 PER CENT. CURES HAVE BEEN OBTAINED

By FRANZ TOREK, M.D.

OF NEW YORK

THE method here described was developed by the author fourteen years ago and has, since its inception, been modified only in details of minor importance, so that there has been ample time to test its value and to avoid jumping at any hasty conclusions.

A previous publication, covering my experience in the first six years, with 304 cases that could be traced, was published in the *Medical Record* of June 22, 1912, under the title "A Contribution to the Study and Surgical Treatment of Oblique Inguinal Hernia." A second series of cases, covering about six and one-half years, up to the end of 1917, consisting of 294 cases that could be traced, makes a total of approximately 600 cases, out of which two recurred, *i.e.*, one-third of one per cent. The first of these was described at length in the former article, a patient who developed gangrene of the abdominal wall, later on found to be of syphilitic origin. The second was a healthy man operated by one of my house surgeons, myself not being present at the operation. As the operation for the recurrence was performed by another surgeon, I am unable to give an authentic explanation of the cause of failure in that case, but I may say that, as the staff man who operated never became a surgeon, and as the case must have been a simple one, we may safely infer careless technic to have been the cause of failure. There is no such thing as a fool-proof method. I believe both of these recurrences should have been avoided, the former by a better study of the man's general condition, the latter by closer attention to details of surgical accuracy, and the results ought to have been 100 per cent. cures instead of 99 $\frac{2}{3}$ per cent.

To the question which has once been put to me whether I have selected my cases, I may say that, if there has been any selection, it has been in a sense opposite to the usually accepted one—I mean that, while the most unfavorable cases would surely be selected for my operation, in the simpler class of cases the assistant would occasionally be permitted to operate by any method he chose.

The salient points in the technic of the operation are the following:

1. Clean separation of the vas deferens and the blood-vessels of the cord from each other as well as from the sac by the removal of all the connective tissue that binds them together, allowing the vas to come out at the bottom of the opening in the transversalis fascia and the vessels to come out at the top of it, while the stump of the sac sinks back between

* Read before the New York Surgical Society, March 12, 1919.

the two. A couple of stitches uniting the muscles to Poupart's ligament keep the vas and vessels permanently separated at the site of the internal ring. The introduction of these sutures applies only to the oblique variety of inguinal hernia.

2. Below the vas suturing of Poupart's ligament to the internal oblique and transversus muscles, and often to the rectus muscle, is continued all the way down to the insertion at the pubis. This is of importance in order to avoid recurrence in the shape of a direct hernia, as well as for the repair of one already existing.

3. The employment of non-absorbable suture material at those parts where there is tension, my preference being silver wire.

4. A number of minor points which might properly be classed under the head of "common sense rules." For instance, the approximation of Poupart's ligament and the muscles must be an absolutely clean approximation, without interposition of any such structures as fat, connective tissue, cremaster muscle, etc.; the alignment must be absolutely accurate; the sutures must be sufficiently close to allow no gaping of tissues between them; they must not be drawn so tight as to cut into or through the tissues they are supposed to unite; when there is much tension, the sutures must be laid closer to each other than in the absence of tension; avoidance of rough handling or tearing of the tissues, etc.

Of these points, the one in which my operation differs radically from all others heretofore described is the first point, the separation of the vas deferens from the blood-vessels of the cord and keeping them separated. The studies which led to the adoption of this procedure have been extensively explained in my previous communication and are here summarized in what follows:

Within the abdomen the vas deferens and the blood-vessels of the cord are apart and separate from each other. At the internal inguinal ring they meet at an angle, the vessels approaching the ring from above downward, the vas from below upward (Figs. 1, 2 and 3). At the site where they meet, an open wedge, or infundibulum, exists through which intra-abdominal structures can force their way out, the protrusion being facilitated by this funnel-shaped arrangement. As a matter of fact, when an oblique hernia is formed, it always wedges its way through between the vas and the vessels. The diagrammatic illustrations by some authors depicting the point of exit for an oblique hernia as being below the cord are incorrect.

In oblique hernia, therefore, the arrangement of the structures at the internal inguinal ring is: Vessels above, vas below, sac between them (Figs. 4 and 6). If this relation is not perfectly evident at the time of operation, the cause is that the said structures have not been prepared entirely clear of the connective tissue which binds them together, and the presence of which obscures the anatomical relations. I wish to emphasize that the statement made above as to the arrangement of these structures

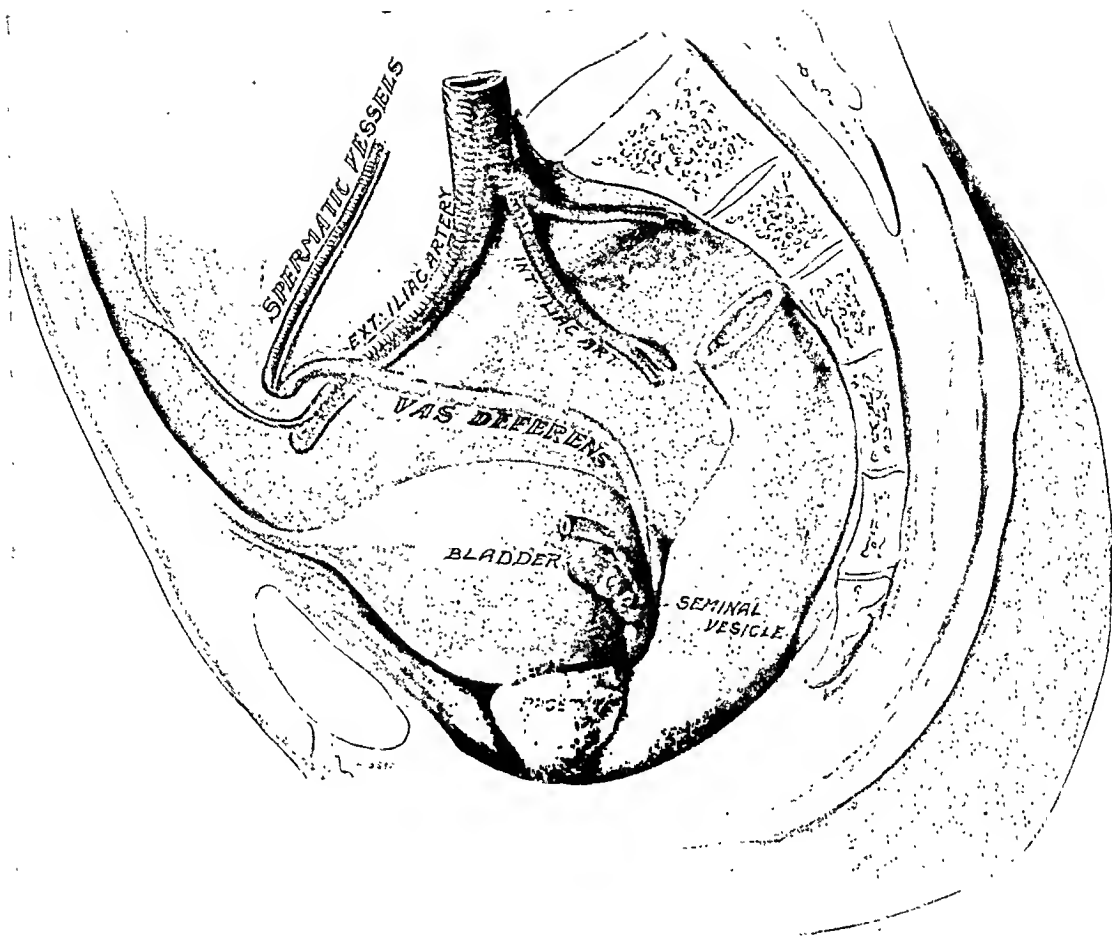


FIG. 1.—(After Spalteholz.) Interior view of lower abdomen and pelvis showing relation of spermatic vessels and vas deferens at internal ring. Lateral view. Observe that vas and vessels meet at an angle, like the two sides of a wedge, thus facilitating the protrusion of a process of peritoneum (compare Fig. 3) and the development of a hernia. The illustration shows the relation in the normal state; in cases of oblique inguinal hernia the internal inguinal ring is enlarged, the vas deferens and the blood vessels being separated by the interposition of the sac (see Fig. 4).

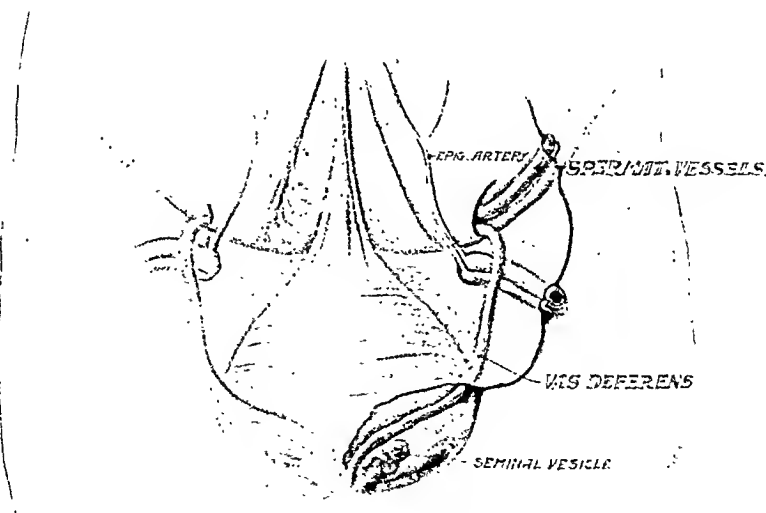


FIG. 2—Same relations as in Fig. 1, seen from behind.

OPERATIVE CURE OF INGUINAL HERNIA

refers solely to *their relation at the opening in the transversalis fascia*. After they have passed beyond that point, their relative position is altered, the sac as a rule lying posteriorly.

The object of the above named "first point" in my operation—separating vas and vessels and keeping them apart—is to deprive the peritoneum and the abdominal contents of the opportunity again to obtrude or force themselves between these two structures, as they could so conveniently do while the wedge-shaped arrangement of vas and vessels existed at the internal ring. This arrangement is abolished by establish-

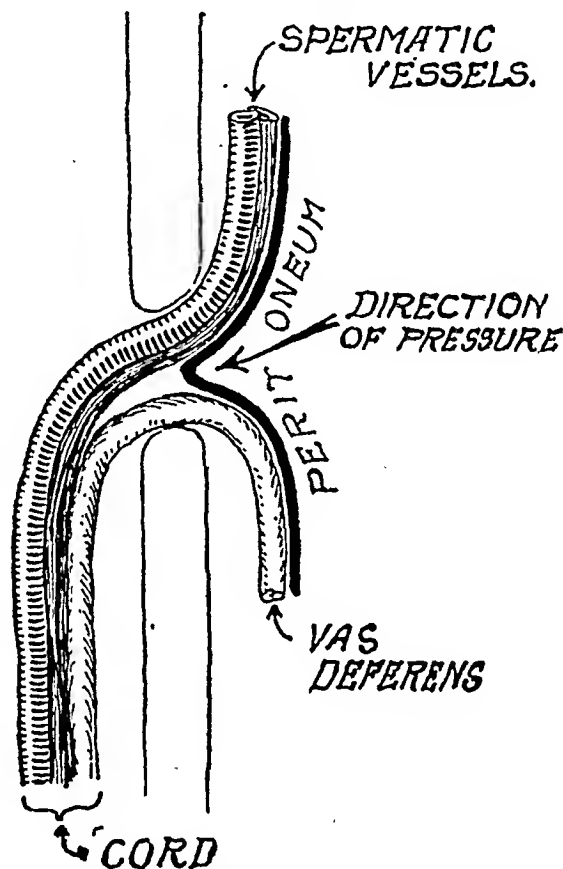


FIG. 3.—Diagram of relations of spermatic vessels and vas deferens at internal inguinal ring. Almost normal, but representing a beginning impingement of the peritoneum into the open angle of the wedge outlined by vessels and vas. Compare remarks under Fig. 1.

ing a firm, square buttress of abdominal wall between vas and vessels, the buttress consisting of internal oblique and transversalis muscle with its fascia on the one side sutured to Poupart's ligament on the other (Figs. 5 and 7). None of the other methods of dealing with the cord take this weak point in the repair of a hernia into account, for they all treat the cord as a whole, and, in consequence, no matter whether the cord is allowed to come out at the lower part of the hernial opening (Ferguson), or is displaced according to Bassini to its upper part, the vas and the vessels still meet at an angle and invite a repetition of an obtrusion of the peritoneum between these structures which afford handsome smooth

gliding surfaces between which a hernia could again wedge its way out.

This method of closure at the internal ring deals effectively with oblique hernia. The remaining part of the plastic, the closure of that portion beneath the point where the vas deferens is brought out, has to deal with direct hernia, for the purpose either of repairing an existing direct hernia or of preventing the occurrence of one in a disposed individual. This part of the repair is of equal importance to that at the internal ring.

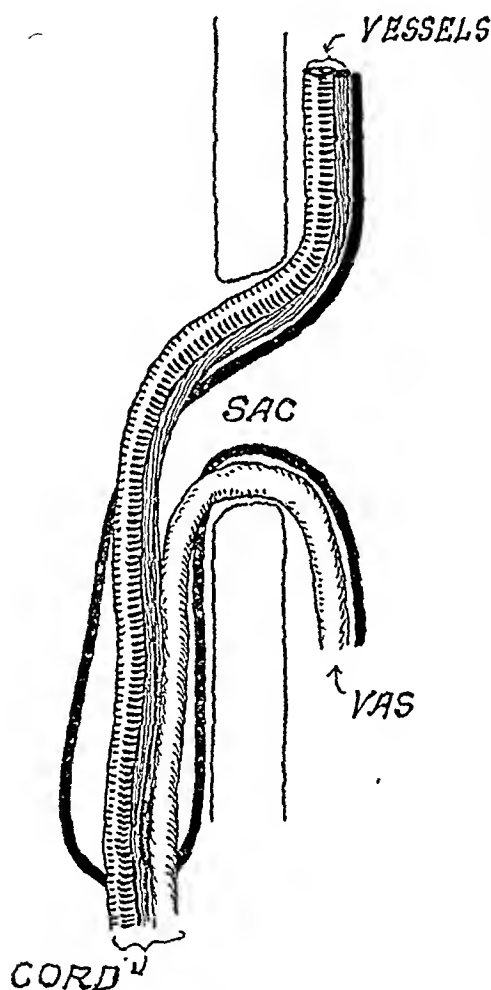


FIG. 4.—Diagram showing the relation of the sac to vas and vessels, the former being below, the latter above the sac. This relative position obtains only at the internal ring; farther down the relation becomes changed.

DESCRIPTION OF THE OPERATION

The skin incision, about four inches long, is made above Poupart's ligament, in the direction of the fibres of the external oblique aponeurosis, terminating mesially at the pubis, superficial to the external ring. Contrary to the recommendation of others who wish to avoid cutting the

OPERATIVE CURE OF INGUINAL HERNIA

superficial vessels at the lower inner end of this incision, and who therefore advise against carrying the incision quite so far down, I am in favor of making it amply large at the lower end. My reason for this is to be found in the great importance, at a subsequent step, of absolute accuracy in the insertion of the lowest one or two sutures that are to hold Poupart's ligament in neat and clean apposition with the rectus muscle or the conjoined tendon. With a free exposure better work can be done in that

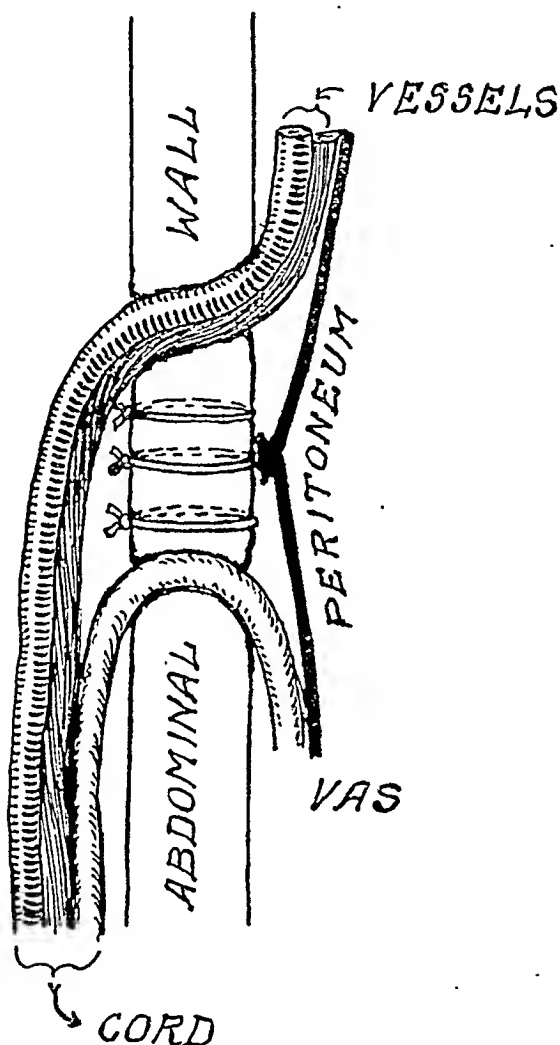


FIG. 5.—Diagram of the upper part of the plastic. Note that the vas deferens and the spermatic vessels are prevented from meeting at the internal inguinal ring by the interposition of sutures between them—sutures which connect Poupart's ligament with the muscles.

important step of the operation, and the additional trouble of dividing and ligating the superficial vessels which cross at the lower end of the incision is well repaid.

The *external oblique aponeurosis* is then incised in the course of its fibres, the incision terminating at the apex of the external inguinal ring. It is then reflected toward both sides, on the outer lower side so as to plainly expose Poupart's ligament all the way down to its insertion in

the pubis, on the inner upper side far enough backward to expose at least a three-quarters inch strip of the internal oblique muscle. The reflection of the aponeurosis here, as on the outer side, should extend all the way down to the pubis. This means that in the lower part the aponeurosis is separated from the rest of the anterior sheath of the rectus muscle. This procedure, though not essential, is nevertheless not quite unimportant, for the rectus muscle, after its release from the aponeurosis of the external oblique, becomes slightly more movable and can therefore more readily be approximated to Poupart's ligament at a later stage of the operation. The margins of the divided aponeurosis may now be held apart, if desired, by retractors or by the application of fine clamps to the cut edges, so as to expose the next layer.

The iliohypogastric nerve is seen coursing along the surface of the internal oblique muscle, often near enough to its free edge to be in danger of being included in the sutures later on to be laid connecting that muscle with Poupart's ligament. If the nerve is well out of the way, it is left undisturbed; otherwise it is dissected free from the muscle, so that it may be held aside when the sutures are inserted. This may be done by slinging it over the inner cut edge of the aponeurosis which in turn is grasped by a fine clamp. The clamp thus keeps the nerve out of the field during the rest of the operation.

The free border of the internal oblique and transversus muscles may now be more sharply outlined if this appears necessary in the given case. Sometimes it is very well defined, at other times the border is in part concealed by fat from a deeper layer. In the latter case a slight incision into the thin fascia which covers both muscle and fat, followed by a little blunt dissection under the muscle edge, liberates the latter and enables us, at a later stage, to procure that *clean* apposition of muscle to Poupart's ligament, without interposition of fat, which is so essential for a successful issue of the plastic.

The cord, together with the hernial sac which is bound up with it by connective tissue, is now lifted out of its bed. This requires tearing of some adipose and areolar tissue and often the ligation of a vessel. The separation of the cord from its bed should be carried well down, so that any attachment at the brim of the pelvis is done away with. This is desirable in order to enable us to attain, at a later stage, that clean apposition of Poupart's ligament to the muscles, without interposition of any other tissue, which has already been alluded to and which is of particular value in the management of the very important one or two sutures at the lower end of the plastic.

The separation of the cord into its elements is now in order. The cord may be slender or bulky, but its essential parts, the blood-vessels and the vas deferens, never take up much room. If it is bulky, the large size is accounted for by the mass of its cremaster muscle, sac, fat, or connective tissue. Everybody, of course, separates the sac, but even to some

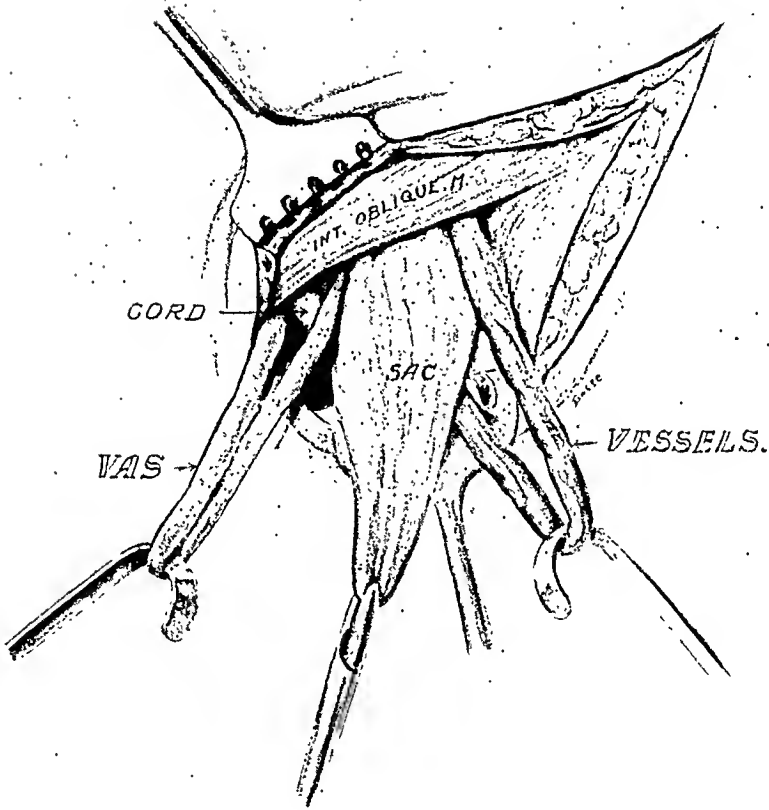


FIG. 6.—Left oblique inguinal hernia. The sac emerges between the spermatic vessels and the vas deferens.

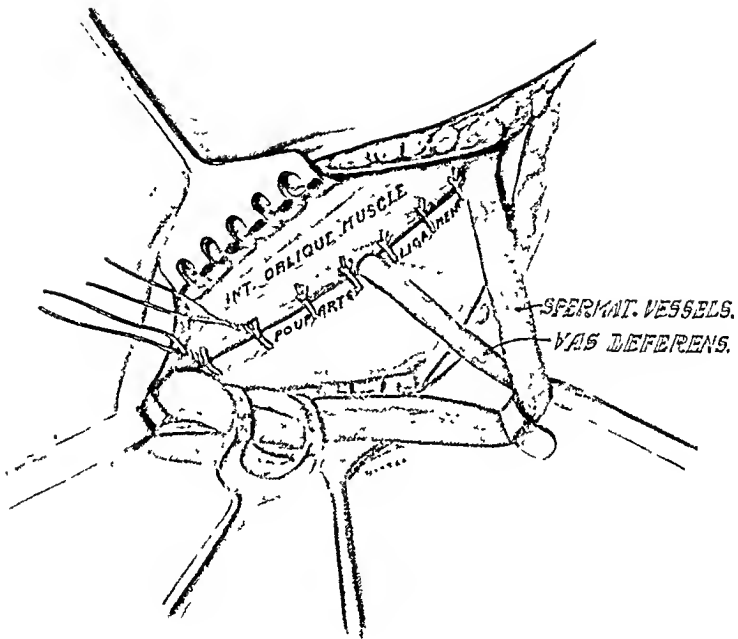


FIG. 7.—Left oblique inguinal hernia. Closure of the deep layer. The internal oblique and transversus muscles have been sutured to Poupart's ligament, three of the sutures separating the vas deferens from the vessels. The vessels emerge at the uppermost angle. The lower two sutures are silver wire, the others chromicized catgut.

of those who separate it high up, as should be done, the anatomical arrangement of the structures at the internal ring, which I have mentioned, may not be evident, if the connective tissue is not dissected off the vas and vessels; for the presence of that tissue will often mask the actual position of these structures. It is, however, desirable that the connective tissue be removed from vas, vessels, and sac, if one wishes to do justice to the principle of clean approximation of muscle to Poupart's ligament without interposition of other tissues. When the connective tissue has been dissected off, the relation of vessels, vas, and sac becomes evident, the vessels coming out above, the vas below, and the sac between them (Fig. 6).

My routine in dissecting the cord is to look first for the vas deferens, which will most frequently be found at the outer posterior part of the cord. This is separated from the rest of the mass and dissected all the way up to the internal ring. Then the vessels are similarly treated, and, when this has been accomplished, we know that we have the most important structures safely out of the way. Next the sac is liberated, and there remain only the cremaster muscle and considerable connective tissue, which latter is resected. In the course of this dissection we often find a good deal of fat, little lipomata, in the course of the sac or cord and extending into the abdomen. These collections of fat must be removed, their presence being highly objectionable; for, as they increase in size, they tend to drag the peritoneum out after them and thus create a condition making it likely for a new hernia to follow down. With the exception of vas and vessels no other structures should be permitted to be partly inside and partly outside the abdomen. They should be either wholly inside or wholly outside, but not within the ring. Here again the principle of clean approximation of the muscles to Poupart's ligament, without any interposition, holds good.

The sac is now emptied of its contents and tied off at the highest point possible. In my former publication I mentioned that in case of large herniæ a purse-string suture of silk is employed for closing the neck of the sac, the suture both beginning and ending on the peritoneal side, so that, when the knot is tied, it will lie on that surface. I wish to state here that I employ this method only in excessively large hernial necks; the vast majority are treated by transfixion and ligation, plain catgut being used for the purpose.

The treatment of the cremaster muscle next deserves consideration. The recommendation has been made to include the cremaster in the sutures connecting Poupart's ligament and the muscles "to give greater strength." I simply mention this proposition in order to condemn it. Far removed from the possibility of giving greater strength, the interposition of the cremaster would most decidedly tend to weaken the proposed union. For the purpose of a strong union we join one firm structure to another firm structure. These are, on the one side, the internal oblique

and transversus muscles and subjacent fascia, on the other side Poupart's ligament. The cremaster muscle, an offshoot from the internal oblique muscle, having no fixed point of attachment below, is, as far as strength is concerned, nothing more than a tail-like appendage the interposition of which between the above named structures would be just as objectionable as the interposition of fat or connective tissue and should under all circumstances be avoided. In many cases it is possible to lift the cremaster up out of the way and to suture the muscles to Poupart's ligament underneath it; at times, however, the muscle is so bulky and so fatty, and its origin from the internal oblique so diffuse as to make it difficult to handle. In such cases I do not hesitate to divide the cremaster at its origin or to resect it, after which a much neater, cleaner, and more satisfactory apposition can be made. I have divided many a cremaster and have never had a patient complain of symptoms ascribable to the loss of its function.

The closure of the deep layer is the next and most important step. The structures to be united are, on the outer lower side, Poupart's ligament, on the inner upper side the internal oblique and transversus muscles with the transversalis fascia and often the rectus muscles at the pubic end. This stretch naturally divides itself into two parts, an upper outer part corresponding to that opening in the transversalis fascia known as the internal inguinal ring, and a lower inner part where normally no opening exists. The upper part has to do with oblique hernia, the lower with direct hernia. Let us first consider the upper part. We have allowed the stump of the sac to slip back out of sight, we have removed all lipomata and other fatty tissue that found its way out through the internal ring, likewise all connective tissue, and we have held the cremaster aside or else have divided it, so that there is nothing emerging from the opening but the vas deferens and the vessels of the cord. We place the vessels into the uppermost angle and the vas into the lowermost angle of this opening. In the ordinary, fairly large hernia these two structures will then be at least an inch apart, giving space for three stitches half an inch apart (Fig. 7). In very large herniæ there will be room for more than three stitches between vas and vessels, while in very small herniæ the distance between vas and vessels may be only half an inch, giving space for only two stitches. There should never be less than two sutures between vas and vessels, for it seems that a single suture is hardly sufficient to overcome that infundibuliform meeting of vas and vessels which is so liable to promote a recurrence of the hernia. The sutures grasp, on the one hand, the internal oblique muscle, the transversus muscle, and if easily feasible the transversalis fascia; on the other hand, the full thickness of Poupart's ligament. As every little detail counts, attention is again called to the last of the above named four salient points, the observance of certain common sense rules. One of these, the avoidance of interposition of tissues between the approxi-

niated edges, has already been repeatedly alluded to. Another one, the demand for an absolutely accurate alignment of the approximated edges, seems self-evident, and yet I have had to call the attention of the majority of the men learning the operation to this point. For instance, after having carried the suture through the muscles, they would then gather Poupart's ligament at a point not directly opposite the one where the muscles were pierced, but perhaps half an inch higher up. In consequence, when the knot is tied, the relation of the two edges will not be natural but strained, the muscles being drawn up out of their proper place or the fascia at Poupart's ligament being split in the course of its fibres owing to the strain, and the result will be a weaker union than we should strive for and can attain by proper alignment. A third point is that the needle should be carried through Poupart's ligament gently, without force, so as to make a hole not bigger than the diameter of the needle; if brute force is employed and the fascia is torn instead of being simply punctured, the result is an impairment in the strength of the union. Those in whose hands the fascia tears have, as a rule, failed to consider that a curved needle, being an arc of a circle, should, in passing through the tissue, proceed in the circumference of the circle of which it forms an arc and not be pushed or pulled through in the direction of a straight line. In sewing skin or some other readily yielding structure this lack of proper technic may be pardonable, but it will never do in the case of a fairly fixed structure like Poupart's ligament. A fourth point is that a reasonable amount of muscle tissue should be grasped in the suture and the full thickness of Poupart's ligament as well. The adaptation of just a thin line of muscle to a thin line of fascia would hardly answer where we must build a wall capable to resist strain. A fifth point refers to the traction employed in tying the knot. What we wish to aim at is a good, firm, close approximation. Anything more than that may result in the suture cutting into or through the tissues intended for union, thus weakening the wall instead of strengthening it, while on the other hand, a suture tied too loosely may fail to bring the parts in proper apposition.

In this upper part of the plastic, the part corresponding to the internal ring, the highest suture is inserted directly under the vessels, which have been placed in the uppermost angle, and the lowest suture directly above the vas, which is in the lower angle (Fig. 7). The suggestion occasionally made of inserting a suture above the cord is not to be considered in this operation. The vessels having been placed in the uppermost angle, there is nothing above them to be sutured.

If we could be absolutely sure that our patient, whose oblique hernia we are repairing, were safe against the development of a direct hernia, the sutures between vessels and vas, just described, would suffice to meet the indication. However, this is not the case; on the contrary, we must consider him prone to develop hernia. The suture of the muscles to Poupart's ligament below the exit of the vas, and from there down to

the pubis, is therefore not only indicated but is imperative, even though an actual direct hernia may not exist.

The management of this lower portion of our hernioplasty is similar to that of the upper portion, just described, in so far as Poupart's ligament is sutured to the muscles opposite, but it differs in some details. First, there is no opening in the transversalis fascia to be closed. Secondly, the internal oblique and transversus muscles do not always run all the way down to the pubis but are more frequently inserted into the rectus fascia at varying distances from the pubis, so that at the lower end of Poupart's ligament we will usually find the rectus opposite to it and must unite it to that muscle. Thirdly, while in the upper section of our plastic there is scarcely ever any tension between the approximated tissues to amount to anything, at the lower part of the lower section tension between rectus muscle and Poupart's ligament is often present, except in women and children where these structures may not infrequently be brought together without much tension. To overcome this tension at the lower end several plans have been suggested, mainly the following two: First, turning over a flap of rectus fascia to be sutured to Poupart's ligament; secondly, incision of the rectus fascia and suture of the liberated rectus muscle to Poupart's ligament. There are objections to these methods, both of which I tried before my own method of operating was developed. The objection to the former is that a flap of rectus fascia, with its base at the outer edge of the muscle, has no hold on the mesial side, there being no posterior rectus sheath. If for any reason a similar flap were formed higher up on the rectus and fastened laterally, any pull on this flap, caused by a strain, would be transmitted through the posterior rectus sheath to the linea alba, thus affording real support to the abdominal wall; at the lower end of the rectus, however, the fascial flap so shaped could not gain a hold on the linea alba through the agency of the posterior rectus sheath, but would, under the influence of a strain, peel off laterally and add a very weak spot at the outer edge of the rectus without itself giving the desired strength at the place where it is sutured. If, on the other hand, a flap is made with its base higher up on the rectus, the insertion of the internal oblique and transversus muscles into the sheath loses in part its strong firm hold, and, in consequence, the upper part of our plastic is weakened. The objection to the other method, the employment of the rectus muscle without its fascia after splitting the latter, is this: If a short slit only is made, extending from the insertion of the internal oblique and transversus down to the pubis, the muscle cannot be sufficiently mobilized, and, if drawn out and attached to Poupart's ligament, will be under such tension that the sutures may easily cut through the muscle. If, on the other hand, the rectus fascia is incised upward far enough to facilitate the mobilization of the rectus, the fixed point to which the internal oblique and transversus muscles are attached, also becomes more movable and, in conse-

quence, those two muscles become slack, thus weakening the upper portion of the plastic of which those muscles play so important a part. I therefore do not open the fascia of the rectus, but draw over the muscle, with its fascia intact, to join it to Poupart's ligament, being satisfied with the slight degree of mobilization afforded by dissecting the external oblique fascia from the remainder of the rectus fascia, as explained above in the paragraph on the management of the external oblique aponeurosis.

The sutures are inserted at three-eighths to one-half inch apart, according to the amount of tension; greater tension requires closer suturing. No gaping of tissues between sutures should be permitted. The lowest suture should be quite close to the pubis. As regards suture material I employ silver, usually No. 26 or slightly heavier for the lowest one or two sutures, the ones where the tissues have to be approximated under tension; for the remaining sutures I use chromicized catgut, usually No. 3. The tension is greatest either at the lowest suture or at the one just above the lowest. In my former publication I stated that I employed silver wire throughout, though I did not wish to be dogmatic as to the selection of the suture material. At present, I have given up the use of silver wire for the majority of the sutures, but I do wish to be emphatic on one point, the use of non-absorbable suture material wherever the approximation is under tension—and that means at the lowest one or two sutures, where the rectus and Poupart's ligament are united. Every surgeon is aware that even the most securely tied catgut knots may open when the suture material imbibes fluid, especially when under tension. But no one knows exactly how long it will take, in a given case, for plastic material to be shed out by such tissues as the rectus sheath and Poupart's ligament in sufficient amount to unite them, nor how long it will take that plastic material to become so strong that it will definitely hold the said structures firmly together. We may, however, be quite sure that such structures as those mentioned are among the slowest to shed out plastic material. The presence of foreign material, on the other hand, encourages the formation of a plastic exudate, as I had occasion to see at an autopsy, described in my former publication, on a case of death from appendicitis in a patient who had been operated upon by me about three months before for hernia. I hold, therefore, that we are taking an unnecessary risk if we employ absorbable material for these particular sutures. Silk or Pagenstecher thread will answer the purpose very well, and in my earliest work I employed silk, but soon changed in favor of silver which appealed to me owing to its slight antiseptic value and the smoothness of its surface. All sutures are inserted before any are tied. We start with the closure of the silver sutures.

The management of silver wire may require a little practice. Silver wire does not lend itself to correction of the degree of tightness of adaptation after it has been twisted. The proper amount of pull must be

estimated and carried out at the first turn given the wire to fix it. Secondly, that first turn should be a complete turn, a half turn not being sufficient to hold the parts together when the suture is under tension. A little experimentation will soon teach anyone how this is accomplished by crossing the two ends of the wire and crossing the hands before tightening up and giving the necessary twist. Then two or three supplementary twists are added. Those who prefer to employ a tool for this purpose will find appropriate wire twisting instruments in the market. Thirdly, the twist in the wire should be placed directly over the suture hole in the muscle, not over Poupart's ligament. The wire is cut off so as to leave an end about one-eighth to three-sixteenths of an inch long. This is turned by the aid of a forceps toward the midline of the body, so as to lie on the muscle; then its distal end is bent a second time so as to embed the point in the muscle, thus putting it where it cannot possibly injure the cord (Fig. 8).

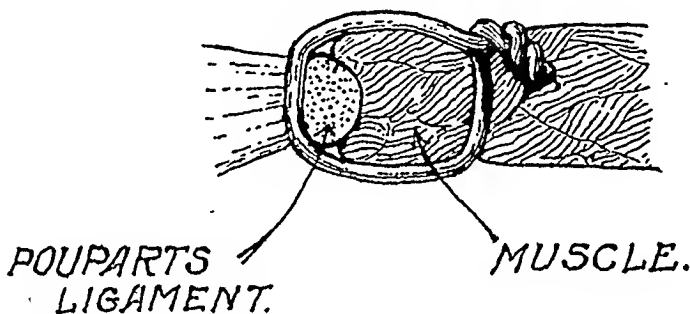


FIG. 8.—Schematic representation of the method of embedding the cut end of the silver wire into the muscle.

There exists, in the minds of some, a sentimental objection against the introduction of non-absorbable material for buried sutures, but there is no doubt that this material, whether it is silk or linen thread or silver wire, has a definite place in surgical technic. The introduction of these little particles of silver wire must not be likened to the use of a silver filigree to which there is a very valid objection. If a silver net is placed in the inguinal region and is subjected thousands of times to a process of bending and straightening out again, as it must be in so movable a part of the body, it is very likely to break. When the use of silver filigree was more fashionable than it is now, I had to remove a number of those appliances because they were broken and the sharp ends caused one or other kind of damage. Not so with the small piece of silver wire used in the individual suture, if the point is properly buried; it will adapt itself to all changes of position of the body. I have recently had the opportunity of operating for femoral hernia in a case where I had operated for inguinal hernia eight years before. Not wishing to disturb the field of my former operation I refrained from doing the Lotheissen operation, which otherwise would have been my choice, but attacked it from underneath

Poupart's ligament and was able to see the small size of my silver sutures as well as the firm hold they had maintained. In that case I had used silver wire sutures throughout for uniting Poupart's ligament and the muscles, as was my custom then; and even lately, in a few cases of very large hernias, where there was tension not only below but also in the upper part of the plastic, I have employed silver wire for all the sutures.

There are still two layers to be sutured, *the aponeurosis of the external oblique and the skin*. But as far as the cure of the hernia is concerned our work is complete when this first, deep layer has been properly attended to. If the deep layer should fail to hold, the aponeurosis of the external oblique will not be able to make good the deficiency, even if it is doubled by the method of overlapping. The external oblique, nevertheless, is sutured, for in the first place it furnishes a neat covering for the cord, and in the next place it supplies a barrier against an eventual stitch infection being carried down to the depth before it is noticed. I must admit that I occasionally experience a stitch infection. A paper that impressed me very much was one by Doctor Brewer in which he reported six months' active hospital work without an infection. I have gone a little less than half that length of time without stitch abscesses, but off and on they still occur.

In conformance with my view as to the slight value of the external oblique in giving strength to the plastic I refrain from doubling it up. The edges are simply brought together by a continuous plain catgut suture, not forgetting to replace the iliohypogastric nerve, if it had been hung over the mesial edge of the fascia. For the same reason I had, until a year ago, made no special effort to carry the suture of the external oblique well down to the pubis. Then I had the experience that a physician brought a patient to me on whom I had operated, claiming that the patient had a recurrence, inasmuch as he could insert his finger into the external ring. I explained my method to him, stating that no effort was made to close the external oblique well down. Then he said he thought there was an impulse on coughing; but I was able to demonstrate to him that the impulse he felt was the handsomest, firmest muscular contraction one could wish for. Since that time I have thought it wiser to close the external oblique well down to avoid disturbing the peace of mind of any patient in whom an open external ring might be discovered.

Speaking of supposed recurrences I might mention another experience. The family physician of a patient on whom I had operated told me he had received word from the patient that he had a recurrence. I requested to have him sent to me for examination. This, however, was delayed and delayed, and when I made the matter more urgent and offered to visit the patient, he could not be found. So I entered him as a case of recurrence, on the strength of the patient's own report. Then,

after about two years' disappointment over the case, the patient had to present himself for military draft, and before doing so, came to my office for examination. It was evident that what the patient had called a recurrence was the development of a hernia on the other side, the operated side being in perfect condition.

The suture of the skin completes the operation. A very small dressing, held by adhesive plaster, is applied. In cases of children and meddlesome patients the application of a spica would be indicated. The patient is kept in bed for two weeks; in exceptional cases a few days longer.

In 17 cases the appendix was also removed by combined operation,¹ and in 6 cases the undescended testicle was brought down at the same time according to the method of orcheopexy I described.²

A separate description of the *operation for direct inguinal hernia* is unnecessary. In speaking of the closure of the deep layer I mentioned that the operative field divides itself into two portions, of which the upper outer, corresponding to the internal inguinal ring, is concerned with the operation for oblique hernia, while the lower inner portion has to do with direct hernia. In cases of direct hernia, therefore, we simply omit the first part of the operation. If the direct hernia manifests itself in the shape of a well defined sac, we resect it, remembering, however, that the protruding part may be the bladder. If there is merely a bulging of the transversalis fascia, we may reef it or leave it entirely undisturbed, simply inserting our sutures in the manner described. A warning of considerable importance, however, must be given. It is absolutely necessary that we ascertain whether we have to deal solely with a direct hernia or with a combination of direct and indirect. In cases of direct hernia we very often find an oblique hernia associated with it. At times the presence of such oblique hernia is quite evident, at other times a small sac is hidden in the upper part of the cord. An anatomical dissection of the vas and vessels, as for oblique hernia, will clear up the situation and should be practiced. The neglect of a small sac at the internal ring would be likely to cause a recurrence in the shape of an oblique hernia, no matter how well the direct hernia had been repaired.

SUMMARY

1. Skin incision about four inches long above Poupart's ligament in the direction of the fibres of the external oblique muscle down to the pubis at the external ring.
2. Incision of the external oblique in the course of its fibres, terminating in the external ring where it also divides the intercolumnar fascia.
3. Reflect the outer margin of the external oblique so as to expose Poupart's ligament all the way down to its insertion in the pubis. Like-

¹Torek: Combined Operation for the Removal of the Appendix and the Cure of Right Inguinal Hernia. *ANNALS OF SURGERY*, May, 1906.

²Torek: The Technique of Orcheopexy. *N. Y. Med. Journ.*, Nov. 13, 1909.

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wise reflect the inner margin of the external oblique all the way down to the pubis, at the lower end separating it from the rest of the rectus sheath.

4. The border of the internal oblique and transversus muscles is freed of connective tissue and fat.

5. Lift the cord out of its bed, liberating it on all sides and entirely loosening its attachments at the brim of the pelvis.

6. Dissect the vas deferens, spermatic vessels, and sac clean of connective tissue well up to the internal ring, until the sac is seen to emerge between the vessels and the vas, the vessels being above the sac, the vas below.

7. Remove all lipomata and other fatty tissue, as well as the connective tissue, from the region of the internal ring, allowing no structure, except vas and vessels, to be partly inside, partly outside the abdomen.

8. Empty the sac, transfix it at the highest point possible, tie, and cut off.

9. Lift the cremaster well out of the way before suturing; do not include it in the suture. If it is unmanageable on account of its bulk or because of a diffuse attachment to the internal oblique muscle, divide it or resect it.

10. Before introducing the sutures, the spermatic vessels are placed in the uppermost angle and the vas deferens in the lowermost angle of the internal ring, these structures being kept apart by the sutures which unite the internal oblique and transversus muscles and transversalis fascia to Poupart's ligament between them. In the average fairly large hernia there is room for three sutures between the vessels and the vas; in very large ones more than three stitches are inserted in this section of the plastic; in no case less than two. These sutures, of which the highest is placed directly under the vessels, close the oblique hernia; below the point of exit of the vas additional sutures, extending all the way down to the pubis, are inserted for the cure of a direct hernia or the prevention of its occurrence. At the lower end of this section, the direct hernia section of the plastic, there is often no internal oblique or transversus muscle available, owing to their insertion in the rectus fascia higher up. In that case the rectus, with unopened sheath, is attached to Poupart's ligament.

11. The sutures are introduced three-eighths to one-half inch apart, greater tension requiring closer suturing, so as to allow no gap to exist between sutures. In suturing observe the following points: The apposition of muscles to Poupart's ligament must be clean, without interposition of connective tissue or fat or cremaster muscle. The alignment must be absolutely accurate, *i.e.*, after the needle has penetrated the muscles, it should catch Poupart's ligament at a point directly opposite, not half an inch higher or lower, as otherwise one or other tissue will tear. Carry the needle through Poupart's ligament gently, so as to make a hole no

bigger than the diameter of the needle. Follow the curve of your needle in going through Poupart's ligament; do not pull it through in a straight line, or else you may split the fascia and weaken your plastic. Grasp a reasonable amount of muscle and the full thickness of Poupart's ligament in your suture. In tying the knot aim at a good firm approximation, no more, no less; a looser suture may leave a gap, while too tight a suture will cut the united tissues, in either case weakening the union.

12. The suture material for the lowest one or two sutures, where the rectus is approximated to Poupart's ligament under some tension, is silver wire, usually No. 26, or some other non-absorbable material; for all remaining sutures chromicized catgut, usually No. 3. All sutures along the whole line are introduced before any are tied. Begin by closing the silver sutures, observing the following: Twist the wire directly over the suture hole in the muscle, not over Poupart's ligament. Estimate the proper amount of pull necessary for good approximation so as to get it right when the first twist is made; an attempt at subsequent correction may break the wire. A complete turn is necessary to hold the parts together when there is tension, therefore hold your hands in such position that a complete turn can be made. Add two or three more twists, cut off so as to leave an end about one-eighth to three-sixteenths inch long, turn this end with a forceps toward the midline, so as to lie on the muscle, give its distal end a second turn so as to embed the point in the muscle.

13. The cure of the hernia depends upon the perfect union of this deep layer and on it alone. The suture of the next layer, the external oblique, serves as a covering over the cord and is done in the simplest manner, without overlapping, using plain catgut. The skin is then sutured. The patient remains in bed two weeks; exceptionally longer.

14. In cases of direct hernia the vas and vessels are found not to be separated at the internal ring; the sutures between vas and vessels are therefore omitted. Otherwise the operative procedure is the same. But make sure that there is not an oblique hernia present besides the direct hernia.

THE TRANSPLANTATION OF THE RECTUS MUSCLE OR ITS SHEATH FOR THE CURE OF INGUINAL HERNIA WHEN THE CONJOINED TENDON IS OBLITERATED. THE TRANSPLANTATION OF THE SARTORIUS MUSCLE FOR THE CURE OF RECURRENT HERNIA WHEN POUPART'S LIGAMENT HAS BEEN DESTROYED *

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ALL surgeons admit a small per cent. of recurrences after operations for the cure of inguinal hernia even when the wound has healed by first intention.

After my study of the results of the operations performed at Johns Hopkins Hospital up until 1899 I felt convinced that the chief cause of recurrence in the lower angle of the wound was due to the fact that, whether the hernia was direct or indirect—the conjoined tendon was either weak or obliterated, and that the ordinary suture or closure of the defect in the abdominal wall was not sufficiently strong to protect from recurrence in the lower angle.

Reports on the ultimate cure of inguinal hernia previous to those of Halsted and Bassini were complicated by the suppuration of the wound. This factor undoubtedly was the chief cause of recurrence; for this reason lesser factors were not discovered.

Practically all surgeons who have contributed to the operative problem of curing an inguinal hernia recognize the importance of the conjoined tendon. From their description it is clearly evident that the conjoined tendon was caught in the lower sutures; the internal oblique muscle was sutured to Poupert's ligament; an effort was made to reduce the size of the external ring and make a snug external ring about the cord.

It is quite possible that the failure to cure depended more on the suppuration of the wound than any fault in the suture. McEwen apparently obtained the best results. In every case after his operations the wound was drained. This procedure may have limited infection. The results, however, must have been discouraging, because McBurney in this country left the wound open to heal by granulation. As far as I am able to ascertain, the results of this method were no improvement over the former methods. It is also quite possible that the brilliant results of Halsted and Bassini may have been due to the improvement in wound technic at that time and perhaps to the more perfect asepsis of their respective clinics, and not to the transplantation of the cord.

When I studied the results in Halsted's clinic I also found that when the wounds supplicated, which was not infrequent in the early years of

* Read by title before the American Surgical Association, June, 1919.

the clinic, recurrence of the hernia was observed in from 25 to 30 per cent. of the cases. However, when the wound healed *per primam*, recurrence was reduced to less than 6 per cent. These recurrences were of two distinct types: One, in the upper angle of the wound, at the position of the transplanted cord, *when the veins were not excised*, usually a small affair, giving very little discomfort and rarely leading to second operation. In the second type the recurrence was in the lower angle of the wound, and my investigations at that time showed that this recurrence had no relation to the position of the cord. It was observed when the cord was and when it was not transplanted, or when the cord was excised or castration performed in older patients.

Fortunately, our excellent notes made before and during the operation on the condition of the conjoined tendon allowed me to conclude that the factor which led to the recurrence was the obliteration of the conjoined tendon at the time of the operation. I have observed both these types of recurrence in patients who have been operated on by the Bassini method, but as my experience with this method is limited entirely to recurrent hernias, I am unable, of course, to obtain any figures as to the exact percentages.

Unfortunately, when Halsted published his first contribution on the cure of inguinal hernia the illustrations and text emphasized the importance of the transplantation of the cord. Nevertheless, in my opinion, this was a minor part of the technic. In one of Halsted's publications he emphasized the importance of closing the defect in the inguinal canal as one would close the wound after any laparotomy—by a most careful suture of all the available fasciæ and muscles without tension with interrupted silk. In Halsted's operation, after the division of the aponeurosis of the external oblique, the division of the covering of the sac, the complete excision of the sac and the closure of the peritoneal cavity high up, the internal oblique muscle was mobilized, so that the conjoined tendon and this muscle could be sutured to Poupart's ligament snugly without tension. During this period surgeons who operated had in mind apparently the transplantation of the cord, and many chose Bassini's method, because it appeared simpler and was less of an operation than Halsted's in which the internal oblique muscle was divided to allow a higher transplantation of the cord. But as far as I can gather, the chief features of Halsted's and Bassini's operation for the cure of inguinal hernia, were the painstaking closure and good healing of the wound.

The objection we found to silk for suture was the increased per cent. of suppurations or stitch abscesses. This led Halsted to change to silver wire which was followed by a better per cent. of healing. Suppuration of the wound, however, was not practically eliminated until gloves were worn at the operation, then it was found that we could return to the employment of silk as a buried-suture material. Due to the great im-

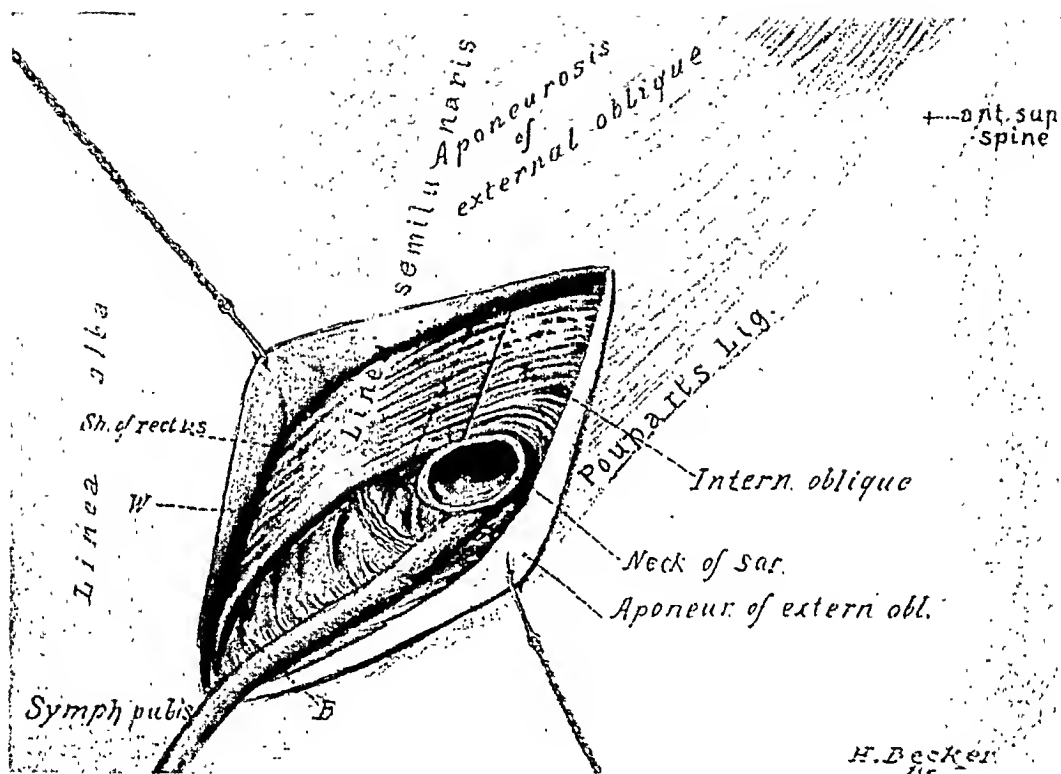


FIG. 1.—Illustrates the anatomy of the inguinal canal.

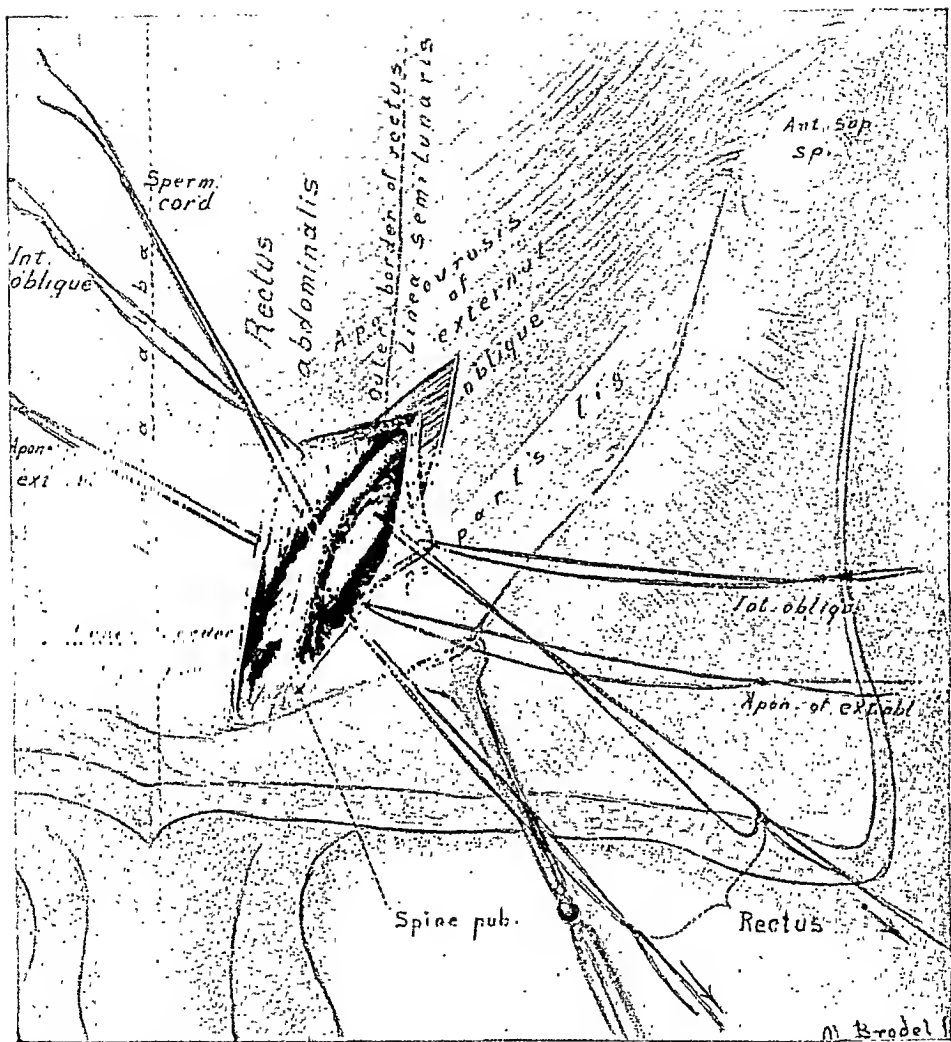


FIG. 2.—My original method of transplanting the rectus with transplantation of the cord—a method from which I got better results than later when the cord was not transplanted.

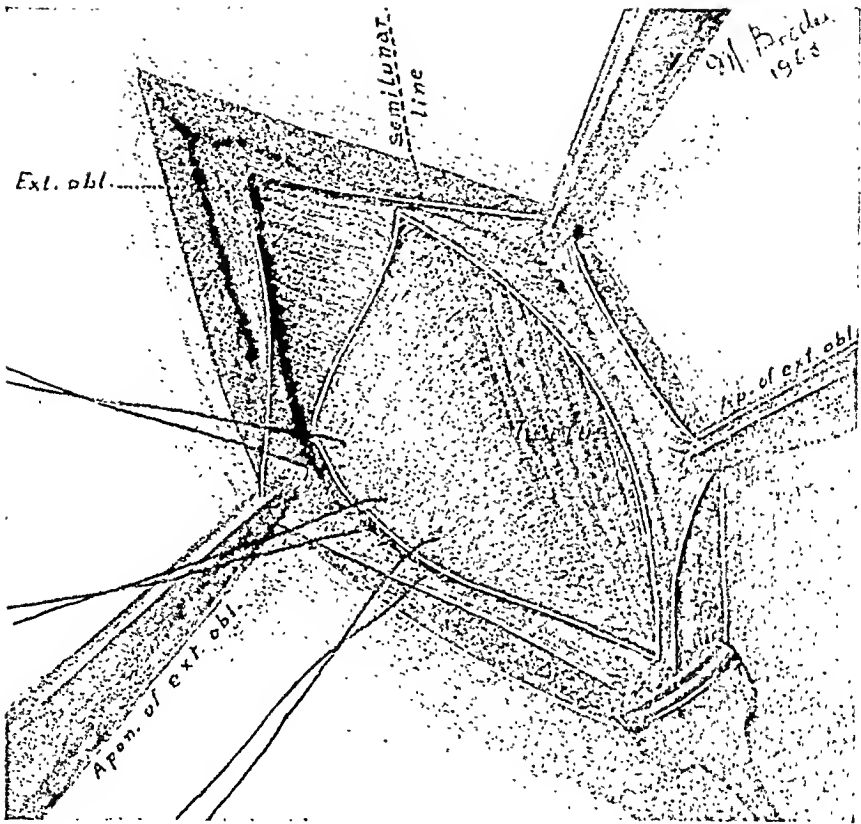


FIG. 3.—Halsted's modification of transplantation of the rectus sheath without transplantation of the cord.

provement in the preparation of chromicized catgut I am now using this suture material in place of silk.

Obliteration of Conjoined Tendon.—My first publication was in 1898 (*Johns Hopkins Hospital Bulletin*, 1898, ix, No. 86), the second in 1899,¹ and not again until 1918.²

During this period I paid much less attention to hernia and operated chiefly on recurrent cases, and my chief interest was centred on that small group of herniæ in which the conjoined tendon was obliterated and which I attempted to cure by the transplantation of the rectus or its fascia (Halsted's modification). A careful following of this small group demonstrated that there was a certain per cent. of recurrences and that the transplantation of the rectus muscle and its fascia was not a certain cure.

During the recent war I had an opportunity to examine in Maryland a large number of selected service men who were placed in Group B because of inguinal hernia. It was very interesting to me to find that the per cent. in which the conjoined tendon was obliterated was about the same as I had found in 1899—5 per cent. As the majority of these selective service men volunteered to be cured of their defect in order to render service, I had an opportunity in a few months to operate on more than one hundred cases.

As I had had recurrences I felt that some modification must be made to the previous method. In this type of hernia, when one invaginates the scrotum and introduces the finger into the external ring, little or no resistance is met and the finger passes over the pubic bone, and, as a rule, can be pushed into the space of Retzius behind the rectus muscle. When this anatomical defect is present on both sides the two fingers meet behind the recti.

The weakness in the abdominal wall is therefore bounded laterally by Poupart's ligament and the rectus muscle, and below by the pubic bone. The firm and perfect closure of this opening is hampered by the presence of the cord.

When I first transplanted the rectus in order to suture it to Poupart's ligament and thus strengthen the defect in the lower angle of the wound due to the obliteration of the conjoined tendon, I also transplanted the cord and excised the veins as in the Halsted operation (Fig. 2).

Since my publication in 1899 we discontinued to transplant the cord and rarely excised the veins, and when this rarer type of inguinal hernia presented itself, we continued the method of transplantation of the rectus, usually with Halsted's modification of transplanting its sheath (Fig. 3), but we did not transplant the cord.

As far as I am able to ascertain, in the group in which I had trans-

¹ Johns Hopkins Hospital Reports, vol. vii, 1899, p. 273.

² Jour. Amer. Med. Ass., Feb. 25, 1918, lxx, 515.

planted the cord (Fig. 2) there has been only one recurrence, but since the change in technic of leaving the cord undisturbed in the lower angle of the wound I know of at least four recurrences in operations which I performed myself, and it seems strange that this made no impression.

The last operation performed by me of this later technic was May 20, 1918. But shortly after this operation a patient on whom I had operated March 16, 1918, suffered a recurrence. This patient had a double direct inguinal hernia; both conjoined tendons were obliterated. The herniæ were of the type of small reducible bubonocèles. In this case both recti and their sheaths were transplanted, but the cord was left undisturbed. It was this recurrence that led me to return to the first method of transplantation of the cord, all but one by the Bassini method. It is too early to judge of the result. All of these patients are in service and have not yet returned.

Report of Case.—In the following case I transplanted the rectus muscle and its sheath without transplanting the cord on May 20, 1918. The conjoined tendon was obliterated. The wound healed *per primam*, the patient entered the army as an officer of the Quartermaster Corps. He was discharged from the army in December, 1918, and in February 20, 1919—ten months after operation—there was a definite recurrence in the lower angle of the wound. For about two weeks before the appearance of bulging there was definite local pain in the region of the external ring.

Anatomical Findings at the First Operation.—The hernia was of the type of a small bubonocèle. The patient was a white male, aged thirty-three, of good muscular development, a little over weight, and of sedentary habits. One could pass the index finger through a large and relaxed external ring directly over the pubic bone into the space of Retzius. The hernia had been observed eight months. No truss had been worn.

There was no hernia or weakness on the left side.

At the operation the external ring was found to be large and split, corresponding to the findings before operation. Above the cord there was a bulging between the internal oblique above, the edge of the rectus to the medial side, and the pubic bone below. This bulging was to the medial side of the deep epigastric vessel. The bulging was covered with fat. It could be easily seen and felt when the patient coughed or strained, as the operation was being performed under local anæsthesia. There was no distinct sac. A triangular flap of the rectus sheath was turned down (Fig. 3), the internal oblique and rectus muscles were mobilized, and all of this tissue was sutured to Poupart's ligament by two rows of chromicized catgut. Then Poupart's was overlapped and sutured to the rectus sheath and internal oblique. Then the aponeurosis of the external oblique was folded over this line of suture and fixed to Poupart's. This is the usual method of imbricated suture.

In this case we had a small bulging of the type of a direct hernia. There was no evidence whatever of the conjoined tendon. From my observation this is the most difficult type of hernia to cure. When the bulging is small, the surrounding fascia and muscle have not been stretched and not thickened by inflammatory reaction, and although we attempt the so-called imbricated suture, we are not able to get much of an overlap, because the tissues have not been sufficiently stretched.

It is in this type that I have had recurrences before in spite of a most painstaking suture and making the ring as snug as possible about the untransplanted cord.

Anatomical Findings at Second Operation.—The recurrence was observed ten months after the first operation, and the second operation was performed two months later. The examination before this second operation was almost identical with that before the first. The finger invaginating the scrotum and following the cord passed over the pubic bone into the space of Retzius, but the tissues about the external ring were much thicker than before the first operation. The recurrent bulging and opening were above and to the medial side of the cord and admitted two fingers.

At the operation the wound having healed so perfectly, we could recognize and separate the anatomical structures just as clearly as in the primary operation. The recurrence was not due to any split in Poupart's ligament on the lower side, or any split in the rectus sheath or muscle on the medial side, but was a definite opening below the line of suture along the cord. At this second operation I transplanted the cord as in Halsted's method. That is, it lay between the subcutaneous fat and the aponeurosis of the external oblique. But I did not split the internal oblique muscle (Fig. 2). This was done, because the aponeurosis of the external oblique was somewhat thickened, and I felt that in view of the scar tissue the cord would be subjected to less pressure and would interfere less with the suture of the lower angle of the wound if I brought it out from the upper angle.

The results of the previous operation had produced thicker and stronger fasciæ and in the imbricated suture I was able to get a wider overlap. The sac in this case was not opened, but somewhat isolated and reduced. In my experience in small direct herniæ not much is gained by opening the sac, and when one pulls it out for high ligation there is some risk of injury to the bladder. I have no evidence to suggest that failure to open, partially excise and close a sac of this kind has anything to do with recurrence.

At this writing, about two and one-half months after operation, the patient is at work and apparently well.

Subsequent to the first operation upon this patient in May, 1918, I have always transplanted the cord when the rectus muscle and sheath had been transplanted, because of the obliteration of the conjoined tendon, and have usually followed the Bassini method of transplanting the cord.

CONCLUSIONS

I have been induced to present this paper before the American Surgical Association, not because the problem of the cure of this type of inguinal hernia is settled, but because of the apparent indifference of the majority of operators to make any change in the technic of their usual procedure, when there is every evidence that the chief weakness is in the lower angle of the inguinal canal due to the obliteration of the conjoined tendon, and not in the usual position, in the upper angle where the cord is situated, and through which the testicle descended.

I have read most of the contributions by surgeons operating in our various training camps for the cure of hernia in soldiers, and thus far I have failed to find a single mention of any change in the technic or to the conjoined tendon, or the transplantation of the rectus or its sheath.

I am confident that this anatomical defect is largely responsible for our recurrences, although these may be relatively few. Some definite change in technic must be made before the number of such recurrences is materially reduced.

There should now be an unusual opportunity, because thousands of men in the selective service and soldiers have been subjected to the operation for the cure of inguinal hernia.

The Transplantation of the Sartorius Muscle for the Cure of Inguinal Hernia When Poupart's Ligament Has Been Destroyed.—I observed some years ago that to completely excise the glands in the groin for primary or metastatic malignant disease, it was usually essential to completely excise that portion of Poupart's ligament corresponding to the inguinal canal.

In three cases of extensive cancer of the penis with metastasis to the glands of both groins, I removed by *en-bloc* dissection the penis, both testicles and cord, Poupart's ligament, everything in the inguinal canal and Scarpa's triangle. To fill the defect left by the removal of Poupart's ligament I divided the sartorius in the middle of the thigh, isolated it except at its upper attachment, placed it over the inguinal canal and sutured it in place.

One of these three patients is living more than five years since operation. There is no hernia on the right side; there is a small bulging and opening on the left side, which gives the patient no discomfort. This case appears to be a pretty good test of the value of this muscle transplantation.

More recently, in two cases of malignant pigmented mole of the leg with metastasis to the glands in one groin I performed the identical operation, except that the cord was not excised, but at least one-half of Poupart's ligament was excised from the pubic bone. One of these patients—an officer in the army—returned to full duty in the infantry. There is no weakness in the scar and no interference with the function of the limb. The result in the second case is equally good.

CURE OF INGUINAL HERNIA

It has recently occurred to me that this muscle could be utilized in some rare cases of recurrent inguinal hernia in which Poupart's ligament has become practically obliterated by previous operation, but I have had no opportunity to carry out this idea since it occurred to me.

Note on the Transplantation of the Cord.—In the great majority of inguinal herniæ where the conjoined tendon is wide and firm and where the internal oblique muscle is well developed and can be mobilized, there seems no difficulty in making a suture without disturbing the cord, or ligating the veins, and the careful study of the results in these cases demonstrates the correctness of this statement.

I feel confident, as already brought out in this paper, that when the weakness in the inguinal canal is in the lower angle due to the obliteration of the conjoined tendon, a proper suture for a permanent cure can only be done by separating the cord from its attachment and transplanting it either by the Bassini or Halsted method.

There will also be a few other cases in which it would seem safer to transplant the cord. In this group the conjoined tendon will be wide and firm, but the internal oblique muscle will be found to be attenuated and very difficult to mobilize.

I have just operated on such a case. The patient had been operated on for appendicitis and drained some twenty-six years ago. One year later a second operation was performed for hernia in the scar. About one year after this second operation a right inguinal hernia developed which finally became scrotal and during the past year difficult to reduce.

Operative Pathology.—The patient was stout, the subcutaneous fat thick and adherent to the aponeurosis of the external oblique. The external ring was not very large, nor was the aponeurosis of the external oblique relaxed. The sac contained omentum adherent to the fundus of the sac. The omentum was ligated and reduced through an opening which hardly admitted two fingers. The remainder of the sac and omentum was removed. The cord in the inguinal canal was larger in diameter than a man's thumb. The internal oblique muscle was attenuated, largely replaced by scar tissue and practically immovable. The conjoined tendon was wide and firm. Poupart's ligament was thickened by scar tissue. This cord was unusually large, and in my experience would act as a factor in recurrence in either the upper or lower angle of the wound. The size of the cord was reduced by isolating, ligating and excising all but the vas and a few accompanying vessels. This mass was composed of numerous thick-walled veins and scar tissue, much larger than the usual varicocele. To excise this mass of veins it was necessary to isolate the entire cord, so that the vas with its remaining vessels could either be left in the lower angle of the wound or transplanted. I found that I could make a better suture of the lower portion of the wound by transplanting the vas, which I did according

to Halsted's method, as the aponeurosis of the external oblique was too attenuated to allow a good covering by the Bassini method.

It is of interest and importance to note here that when I reported on the results in the Halsted clinic in 1899, we were unable to find a single recurrence in the group in which the cord had been transplanted and reduced in size by the excision of the veins, and in which the conjoined tendon was wide and firm. The only objections to this method were a very few cases of atrophy of the testicle and hydrocele. But in my contribution I demonstrated that atrophy of the testicle depended upon hemorrhage from the lower stump of ligated veins, and with good technique the veins could be excised without any danger of atrophy of the testicle. But there is always the possibility of a hydrocele.

There should be no question in the mind of the surgeon or the patient that it is better to run the risk of a hydrocele than of a recurrence of the hernia, and I am confident from my experience that in some cases of inguinal hernia the cord should be reduced in size by a most careful ligation and excision of the veins, and in a small group the lower portion of the wound can be closed better by the transplantation of the cord. So far as I am able to observe, it makes very little difference whether this is done by the Bassini or by the Halsted method.

STRANGULATED AND IRREDUCIBLE HERNIÆ

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THE purpose of this paper is to call attention to and to discuss several forms of operative technic, varying from the normal, which have proved to be of life-saving value in the treatment of the acute emergencies produced by the strangulation of various herniæ.

In any discussion of the subject the question of the choice of anæsthetic is an important one, and, while, in the minds of experienced operators, there does not seem to be much doubt but that local anæsthesia is the anæsthetic of choice, yet it is believed that individual cases admit of considerable variation in regard to the use of local or general anæsthesia.

It is recognized, of course, that for the patient with a strangulation of over six to eight hours' duration, in whom there is vomiting, distention, and unsatisfactory pulse, local anæsthesia would be ideal, and in practically all strangulated herniæ which are not large and which have not been previously incarcerated or traumatized by attempts at taxis, this is so.

But a differentiation must be made, for there are many herniæ previously incarcerated, or of long standing, or which have been subject to trauma, in which there are so many adhesions or œdema present that the separation both of the sac from the surrounding tissues and of the adhesions inside the sac is extremely difficult and painful under local anæsthesia, so that the effort to separate such adhesions may result in more shock to the patient than if the operation had been more quickly done under a skilfully given light ether anæsthesia.

It is rare that this type of case is suitable for gas-oxygen anæsthesia, both because the patient is probably in a more or less starved condition and also because of the probable operative difficulties under this anæsthesia.

In the simple case of short duration and with a fairly small hernial sac, local anæsthesia is ideal, but in this type of case, on the other hand, there is generally no contraindication to ether, and some patients much prefer it. It is, therefore, customary when there has been no contraindication to give the patient his own choice of anæsthetic in this type of case. Results have been uniformly good whether a local or general anæsthetic was used.

The preference, however, is for local anæsthesia, as it is also in practically all simple uncomplicated cases of hernia.

The anæsthetic, whether local or general, has always been preceded by the appropriate dosage of morphia alone, if local is used, and morphia and atropin if a general anæsthetic is used.

Local preparation of the operative field has been with full strength iodine, preceded by benzin and followed by cleansing with alcohol. Thus

all possibility of skin irritation from too long contact of the iodine or of possible irritation of the intestinal coats, should they accidentally come in contact with the skin surface, is avoided.

When fecal vomiting has occurred, the stomach is always washed out before the patient is given a general anæsthetic, and after operation and before the patient leaves the table in cases under local anæsthesia when the general condition well permit. This makes the first twenty-four hours of convalescence decidedly more comfortable and also definitely reduces the danger of inhalation pneumonia.

Technic and Methods of Operation.—Our results, especially our primary mortality in these acute cases, will depend largely on two factors: (1) Technic, and (2) proper judgment as to the kind of procedure to employ.

As an introduction to the discussion of these two factors we would state that it is believed that in any case in which the viability of the strangulated gut is in question a two-stage operation is *always* indicated, and that the abdominal cavity should never be opened elsewhere than at the site of the hernia at either the primary or secondary operation. The following points in technic will serve to give the reasons for the above statements:

Technic.—In inguinal herniæ the routine incision for radical cure in uncomplicated cases, parallel to Poupart's ligament, is generously made, but in femoral herniæ this incision is shortened at the top and lengthened below and slightly curved outward so as to carry it over the femoral canal in order to give ready access to the lower end of Poupart's and all of Gimbernat's ligament, as described by Moschcowitz, Tupper, Lotheisen and others.

The author believes it is rarely necessary to actually divide Poupart's ligament in dealing with strangulated femoral herniæ. The constriction of the femoral canal can, on the other hand, be relieved by one of two methods. (1) By merely nicking the under surface of this ligament or partially dividing Gimbernat's ligament, or (2) (and this method is much preferred and has been found very satisfactory in several recent cases) the femoral ring or point of constriction can be *stretched* by the aid of two small retractors so that the hernia can be reduced or, in cases in which it is necessary, room enough can be obtained in which to pull down healthy intestine far enough to allow one to do resection *in situ* outside of the abdominal cavity and outside of the femoral ring.

This technic of stretching the femoral ring has been carried out in cases under local as well as under general anæsthesia with very satisfactory results. Partial severance of Gimbernat's ligament serves to give added room when necessary, and does not destroy an anatomical structure which is absolutely necessary for later radical cure. The severance of Poupart's ligament, it is believed, is contraindicated except in extreme cases because local wound sepsis in this region is very liable to follow and a necrosis of the ligament is liable to ensue with eventual weakening of

this part of the abdominal wall and unsatisfactory results from later attempts at radical cure of the hernia.

Questions of Judgment.—(a) Indications for the two-stage operation; and (b) contraindications against opening the abdominal cavity above or at any other site than at the inguinal or femoral openings.

(a) It is believed that the two-stage operation is always, and invariably, indicated (1) when there is reasonable question of the viability of the strangulated segment of intestine, and (2) when resection is unquestionably necessary. This belief is further confirmed by a review of hospital case histories showing nearly 100 per cent. mortality in cases where an attempt to resect and anastomosis at the primary operation is made.

If a hernia has been strangulated long enough or tight enough to destroy the vitality of the contained segment of intestine, then the patient has of necessity absorbed enough toxin from this area to make a one-stage operation unsafe. This point is further confirmed by the satisfactory convalescence made by those in whom a two-stage operation with immediate drainage of the involved, congested gut is done. This drainage should be kept up, not for a few days only, but for several weeks, until all signs of toxæmia have disappeared, wound sepsis has cleared up, and the patient is in a sufficiently improved condition for the anastomosis and radical cure of his hernia. Here again hospital case histories show the mistake in judgment of attempting the second operation much before the lapse of at least three weeks.

(b) The abdominal cavity need not and should not be opened other than at the site of the hernial opening in order to do the second stage of the logical two-stage operation.

Contraindications are: (1) danger of peritonitis; (2) difficulty of freeing ends of intestine from hernial opening when approached from within the abdomen, without, of necessity, soiling the peritoneum and making drainage of the wound necessary; (3) the ease with which an anastomosis can be done outside the hernial ring, the intestine returned to the abdominal cavity, and a radical cure be done with provision made for drainage only of superficial tissue; and (4) the greater risk of the double as contrasted with the single operation at this time.

The routine procedure of two-stage operation in strangulated femoral hernia is outlined below:

Anæsthesia preferably local; opening of sac to determine condition of contents; stretching of femoral ring, possibly further aided by nicking Gimbernat's ligament; pulling down of healthy intestine; resection of devitalized gut; insertion of Mixter drainage tubes into each cut end; stay sutures holding intestinal ends well outside of wound; small drainage wicks; closure of skin to tubes; after a lapse of three weeks, local anæsthesia; careful freeing of ends of intestine from edges of wound; further stretching of contracted tissue about femoral ring; end-to-end anastomosis; cleansing of joint; return to abdominal cavity through

relaxed femoral opening; radical cure of hernia with drainage to superficial tissue only.

Three recent cases done by this technic made splendid recoveries when the chances seemed poor and two other cases, one femoral and one inguinal, done over a year ago, show no signs of recurrence of their herniæ at the present date.

The principal advantages of the method described and used in a series of twelve cases are:

1. The shortest and least traumatizing primary operation possible when the patient is in poorest condition.

2. The great benefit from prompt and continued drainage of the strangulated gut.

3. The minimum risk of peritonitis; the operation being practically extra-peritoneal and the risk from peritoneal infection is therefore practically *nil*.

4. Avoidance of cutting structures like Poupart's ligament which do not tend to heal readily and the obtaining of sufficient room for reduction of the hernia—or for resection and later repair of the hernia—by the method of stretching the femoral ring.

5. The strong evidence against opening the abdomen elsewhere to do resection or anastomosis as evidenced by the high mortality in the one-stage operation.

It is, of course, realized that the advocacy of the two-stage, draining-*in-situ* operation admits of the probability of more or less local sepsis in the hernial wound, but results so far, both immediate and at the end of one year, still lead us to believe that the risk of such wound infection is of comparatively little importance in comparison with the benefits derived from the intestinal drainage effected and the materially lowered mortality when this is done.

Such technical errors as the following are found on analysis to be the definite cause of high mortality and illustrate our points of discussion:

1. Strangulated inguinal hernia, seventy-two hours duration. Poupart's ligament severed. Resection of intestine for gangrene. Drainage *in situ* with Mixter tubes, but second operation for end-to-end anastomosis done after the lapse of only one week in a dirty field and followed by general peritonitis and death.

2. Strangulated inguinal hernia, forty-eight hours duration. Resection and faulty end-to-end anastomosis done *in situ*, one-stage operation followed by intestinal obstruction; later lateral anastomosis, intestinal obstruction and death.

3. Strangulated inguinal hernia, forty hours duration. Median abdominal incision. Intestine ruptured in attempt to free it from the sac from within. Patient died of general peritonitis.

4. Strangulated inguinal hernia, seventy hours duration. General condition only fair. Ether. Resection and end-to-end anastomosis, one-stage operation. Death pneumonia. General peritonitis.

5. Strangulated femoral hernia. Ether. Median abdominal in-

cision. Resection and end-to-end anastomosis of intestine. Radical cure of hernia. Died of secondary shock. One-stage operation.

6. Strangulated inguinal hernia, three days duration. Gangrenous sac and intestine. End-to-end anastomosis after resection *in situ* necessitating drain to inguinal canal and failure of anastomosis to hold because of sepsis present. Fecal fistula in inguinal canal necessitating opening abdomen at later (but too early for walling off) date for partial obstruction and death from general peritonitis.

It is believed from the results obtained, even in our very limited number of cases, that the procedure advocated should more often result in the recovery of the patient than the more formidable one-stage operation which is so often attempted by surgeons with the belief that the case is a border-line case and probably will stand the shorter one-stage resection and anastomosis rather than the more prolonged confinement necessitated by the two-stage operation. But this very point of judgment is what this paper wishes to call attention to, and to emphasize the fact, based on past poor results, that, as stated above, any strangulated hernia that requires resection of intestine of necessity requires the two-stage operation.

We are positive that many more lives will be saved by this procedure than if the old method, with its uncertainty of outcome, is adhered to.

It is desired to call attention to a rather unusual but successful method of dealing with an irreducible scrotal hernia of the bladder of long standing.

The case history, technic employed, and results are as follows:

A. T., fifty-six years old, an Italian laborer doing heavy work in lumbering camp for many years, had one week previously entered a large general hospital where a diagnosis of hernia of the bladder, enlarged prostate and hypertension had been made and operation advised against because of his general appearance, general condition, weight, and the nature of his hernia. He was later seen by his local doctor who referred him to the author for operation.

For nineteen years patient has had a left scrotal hernia of large size. He has always had great difficulty and much pain in reducing it, and for the past four years has been unable to do so at all. In the past year has had great difficulty in urination, but has found that persistent manipulation of his scrotum, especially in making motions of a more or less rotary character, greatly facilitated the passage of urine and that the hernia is smaller after urination is completed. The bowels are regular without medicine and he has no other symptoms except urinary urgency and difficulty in starting the passage of water.

Physical Examination.—A short, thick-set, large-framed Italian weighing 375 pounds. Mouth and throat not remarkable. Heart and lungs negative except for slight hypertrophy of heart consistent with

his size. Blood-pressure systolic 150, diastolic 80. Abdomen very prominent. No masses or tenderness. Left side of scrotum contains a large, soft, fluctuating tumor, the size of a large grape fruit. It is not reducible and apparently contains fluid. Rectal examination shows a very slightly enlarged, firm prostate. Attempts to pass a catheter or cystoscope unsuccessful. Catheter meets a definite obstruction after it has passed the prostate apparently. After voluntary micturition tumor of scrotum is diminished about one-half in size, but is still irreducible and catheterization is still impossible. Urine negative.

Diagnosis.—Scrotal hernia of bladder and probably omentum. Operation advised and accepted with the reservation that the testicle should not be sacrificed unless absolutely necessary. Patient sent to hospital for forty-eight hour pre-operative bi-daily local preparation. Given methylene blue three times a day for two days previous to operation in the effort to stain the bladder wall so as to render it more easily distinguishable from surrounding structures.

Operation.—A most skillful, lightly given ether anæsthesia by Dr. Frank L. Richardson rendered the operative difficulties much less. Usual left inguinal incision carried well down into scrotum. Great difficulty experienced in locating the part of the sac where the bladder was not adherent. Sac finally opened and found to contain bladder only, which was everywhere firmly adherent. It was found impossible and inadvisable to attempt to dissect bladder free from its almost complete surrounding of adhesions. It was impossible to dissect even the cord from the sac and bladder wall and, respecting the patient's desire to save the testicle, it with the cord, sac and bladder were freed from the scrotum, invaginated together, and pushed *en masse* gently through the stretched inguinal canal into the abdominal cavity and a radical cure of the left inguinal hernia done. Immediately after operation the patient was catheterized with great ease. He made an absolutely uneventful convalescence, voiding regularly without difficulty or pain, left the hospital on the twentieth day and has been free from symptoms since. When last seen about six months after operation he had had no pain from his abdominally housed testicle, no urinary symptoms, and no recurrence of his hernia.

The point we desire to emphasize in reporting this case is the possibility, when extensive adhesions make wide dissection of such a hernia inadvisable, of placing an adherent cord and testicle within the abdominal cavity, together with its adherent hernial sac (or bladder), doing a radical cure of the hernia and expecting a favorable, symptomless outcome.

ROENTGEN EXAMINATION OF THE ABDOMINAL ORGANS FOLLOWING OXYGEN INFLATION OF THE PERITONEAL CAVITY *

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THE introduction of air or gas into body cavities as an adjuvant of röntgenology is not, as is sometimes erroneously assumed, entirely new, for the procedure has been repeatedly employed in the past as a diagnostic aid in röntgen examination of the urinary bladder, renal pelvices and of the knee-joint in particular. Credit for the original idea of air inflation of the peritoneal cavity for diagnostic purposes must be given to Kelling, who, in 1902, employed this method of inspecting the abdominal contents of two human beings, one a case of ascites, the other a carcinoma of the stomach in a woman with very relaxed abdominal coverings.

Eight years later, in 1910 and 1911, Jacobaeus of Stockholm revived the method and emphasized the safety of the abdominal puncture in these cases on the basis of over twenty experiments on cadavers in which the trocar was pushed through the abdominal wall and invariably reached the peritoneal cavity without damaging the viscera. Excellent results were obtained by him later on in seventeen cases of ascites, including three very remarkable diagnoses (metastatic nodule in the liver, gastric cancer, general carcinosis of the intestine). A monograph on the subject of laparo- and thoracoscopy under air inflation was published by him in 1913, wherein conditions are described as relatively favorable in the living subject because of the yielding and elastic character of the intestinal walls.*

It was only a step, although a most important one, to the application of the method of abdominal inflation to the röntgenological technic. Weber, working in the Private Institute for Röntgen Diagnosis of Doctors Eugen Weber and V. von Bergmann in Kiew, in January, 1912, conceived the idea, based on the Röntgen examination of a bladder filled with oxygen, showing a good röntgenogram of the hypertrophied prostate, that the introduction of sterile inactive oxygen or air into the abdominal cavity might help to render visible a number of organs, tumors and abdominal areas which heretofore had been more or less inaccessible to Röntgen examination. Experiments on animals and on fresh cadavers of adults and children entirely confirmed his

* Read in part before the American Association for Thoracic Surgery, June 9, American Gastro-enterological Society, June 10, and the American Surgical Association, June 16, 1919.

theory. His röntgenograms showed that the following viscera and areas may be rendered visible by means of gas inflation of the abdomen: (1) The liver and spleen as a whole, including the region of the gall-bladder. (2) Coils of the large and small intestine without bismuth filling. (3) The pyloric portion of the stomach. (4) The walls of the stomach and large intestine with gas contents. (5) The bladder filled with urine. (6) Parts of the mesentery. (7) The subphrenic space, not readily accessible to diagnosis. (8) Many intra-abdominal tumors.

He emphasizes the far-reaching importance of air or oxygen inflation of the abdominal cavity for experimental and diagnostic röntgenology and lays stress on the value of the method for obtaining good röntgenograms of the liver and biliary region as well as for the röntgenographic representation of tumors and inflammatory swellings.

In 1912, Lorey, in connection with the demonstration of a peculiar case of ascites, pointed out that after the introduction of air or nitrogen into the abdominal cavity it was possible to demonstrate the contours of the spleen and liver with great clearness and to recognize the existence of tumors projecting above the surface as well as other pathological changes. The method was employed by him after puncture of ascites in a case of hepatic cirrhosis with good results.

Systematic experiments for the purpose of rendering the liver accessible to röntgenography were carried out in 1914 by Rautenberg, who introduced air by puncture into the abdominal cavity in diseases of the liver complicated by ascites with the object of obtaining more distinct contours of both liver and spleen. He fully appreciated the diagnostic value of the method and recommended it as affording remarkable information concerning the organs situated below the diaphragm. Conditions such as carcinoma of the liver, sarcoma of the spleen, etc., were recognized by means of this method. He contributes four interesting illustrations, one of which shows peritoneal carcinosis and cancer nodules in the diaphragm. The liver in this case was seen to be smooth and the spleen normal following puncture of ascites and oxygen inflation of the peritoneal cavity. In a patient with hepatic cirrhosis who was röntgenographed in the left lateral position the liver was revealed misshapen and irregular. In a case of degeneration of the heart muscle with general stasis röntgenographed in the same position the liver was shown to remain convex and vaulted. A normal pneumo-peritoneum taken in the left lateral position showed the right hepatic lobe spread out flat and horizontal.

Another contribution to the subject was made by Meyer-Betz, who in 1914 discussed the clinical importance of röntgenographic representation of the liver by means of air or oxygen inflation of the free abdominal cavity. He pointed out that under correct employment this procedure affords valuable assistance in the determination of the starting point of tumors in the abdomen and their relation to the other organs of the abdominal cavity.



FIG. 1.—A, spleen; B, liver; C, diaphragm; D, left kidney; E, heart.

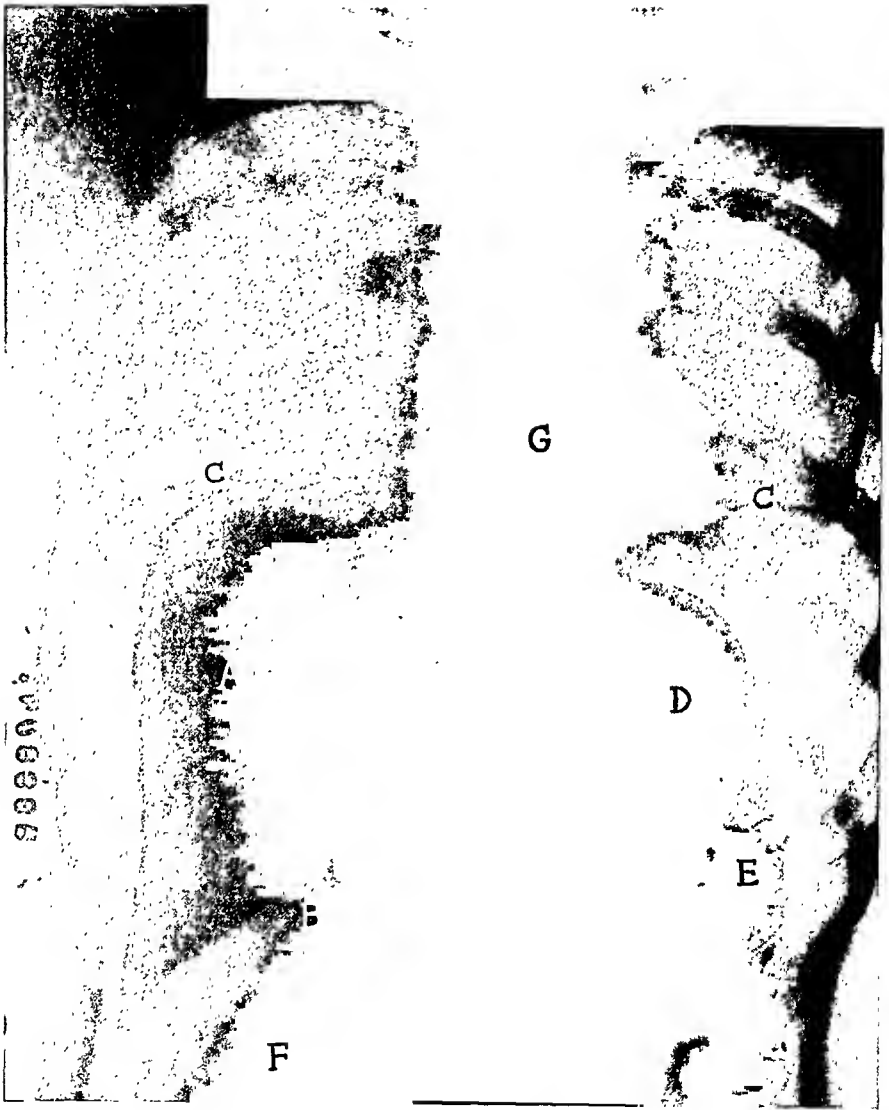


FIG. 2.—A, liver; B, gall-bladder; C, diaphragm; D, spleen; E, splenic flexure of colon; F, right kidney; G, heart.

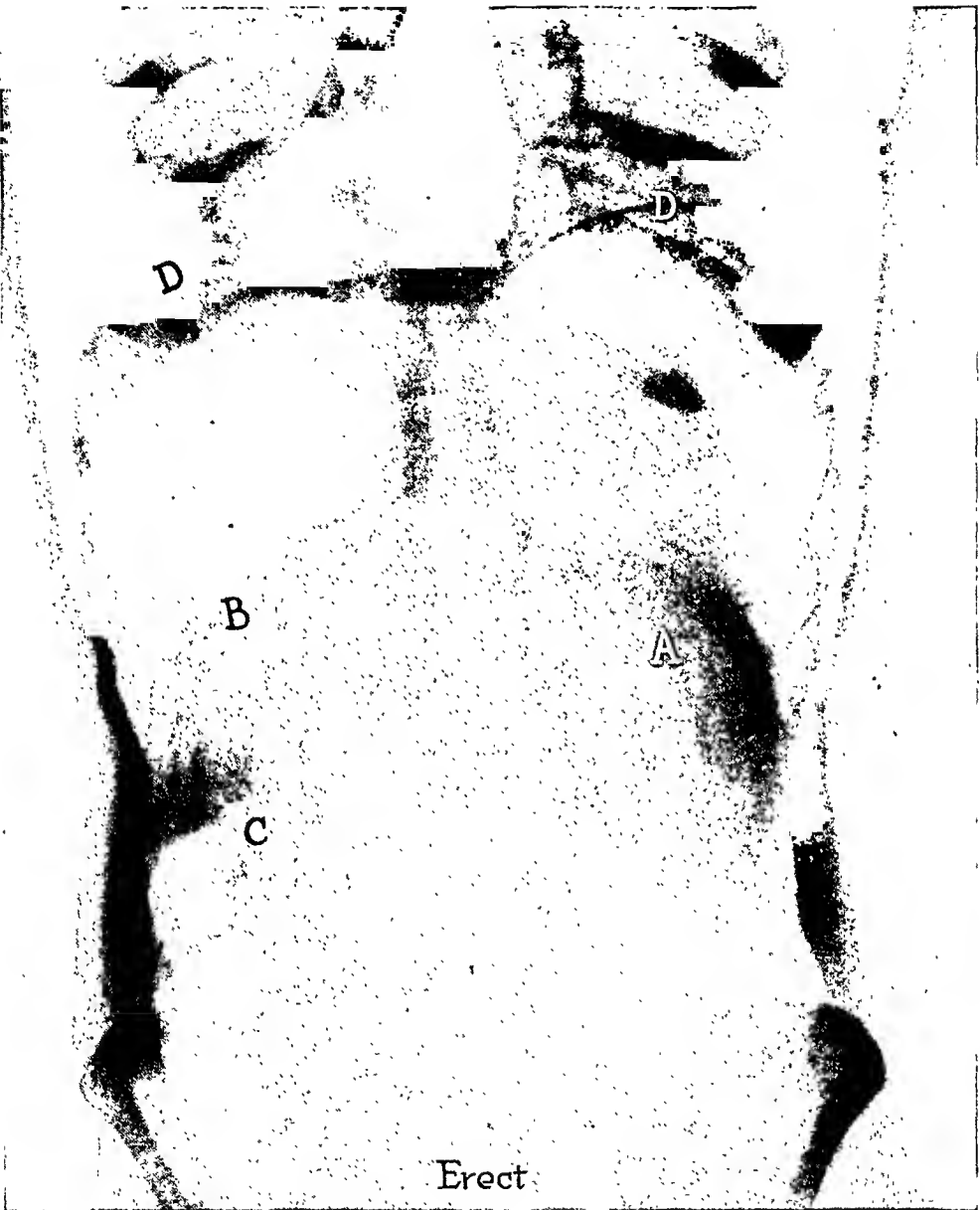


FIG. 3.—Patient in erect position. *A*, liver; *B*, spleen; *C*, right kidney; *D*, diaphragm.



FIG. 4.—Patient in erect position. *A*, liver, *B*, spleen, *C*, right kidney, *D*, left kidney; *E*, splenic flexure, *F*, colon descendens



FIG. 5.—*A*, kidney; *B*, spleen; *C*, oxygen.



FIG 6 — 4, liver, *B* diaphragm *C* heart, *D* spleen *E* pedicle of spleen, *F* left kidney, *G*, right kidney, *H*, four enlarged mesenteric glands, *I*, enlarged cystic ovary, *J*, mass involving right tube and ovary



FIG. 7.—A, enlarged lobulated spleen; B, diaphragm.

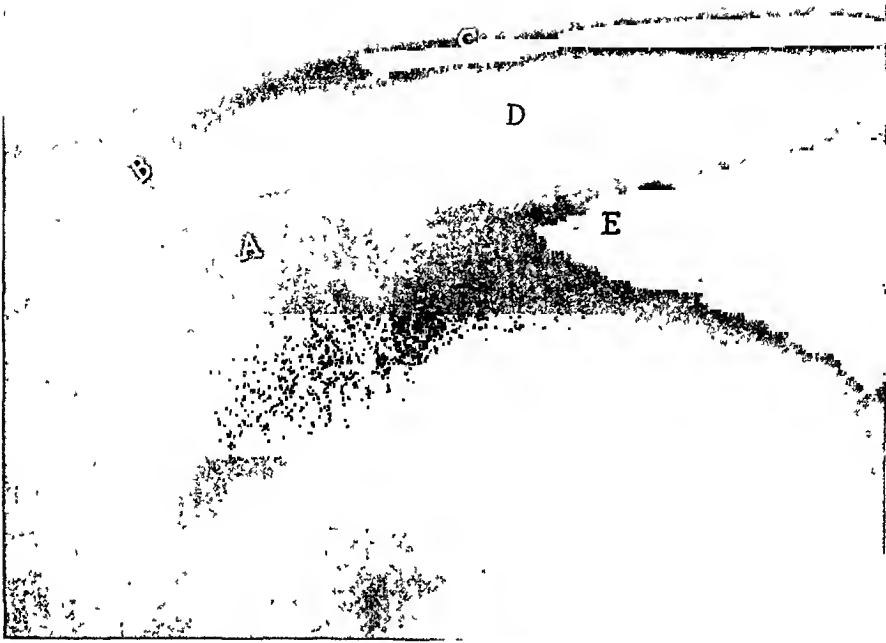


FIG. 8.—A, liver; B, diaphragm; C, abdominal wall; D, oxygen; E, intestinal coils.

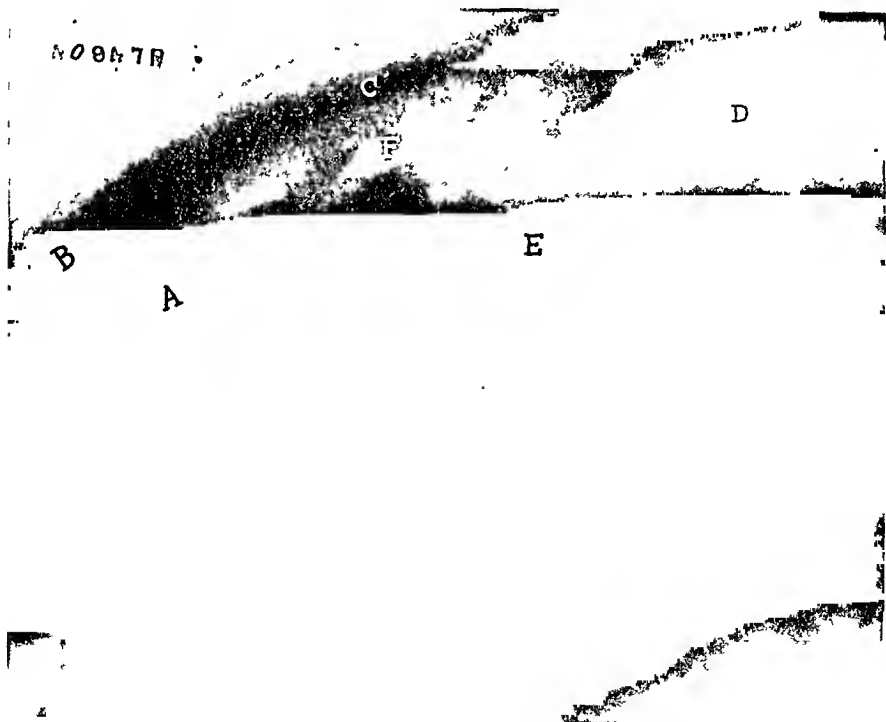


FIG. 9.—A, liver; B, diaphragm; C, abdominal wall; D, oxygen; E, intestinal coils; F, intraperitoneal adhesions.



FIG. 10.—A, spleen; B, kidney; C, colon descendens; D, caecum; E, fundus uteri; F, bladder; G, broad ligament; H, left ovary.



FIG 11 — 4, myoma uteri; B, stretched round ligaments, C, pedunculated fibroid

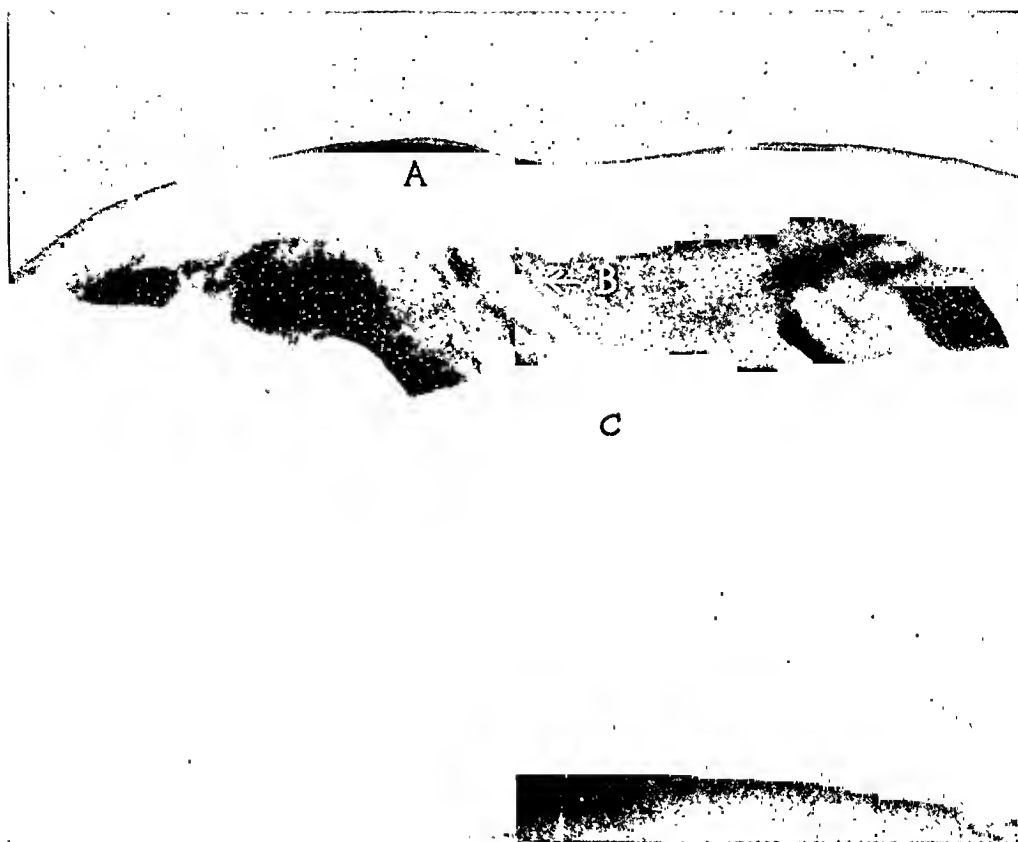


FIG. 12.—A, abdominal wall; B, intraperitoneal adhesions; C, coils of intestines.



FIG. 13.—A, left kidney.



FIG. 14.—A, enlarged right kidney, B, liver; C, adhesions; D, bladder distended with air.

In November, 1918, Goetze, in apparent ignorance of the work of his German predecessors along these lines, with the exception of Rautenberg, reported very remarkable röntgenographic data concerning nearly all of the abdominal organs on the basis of a large number of experiments on living subjects secured by filling the abdominal cavity with oxygen before taking the röntgenograms.

Judging from the accessible literature the diagnostic method of oxygen or air inflation by abdominal puncture in combination with röntgenology has not been introduced in France, where röntgenological control of therapeutic pneumothorax was proposed by Rist and Maingot in 1912.

In a Paris thesis (1912) on radioscopy and radiography of the spleen, Le Page mentioned inflation into the joints and into the stomach as a general diagnostic procedure. Gastric inflation was employed not only for the examination of the stomach itself, but also for the diagnosis of pericardial exudates.

Béclère advocated inflation of the stomach and colon for the examination of the lower surface of the liver and the search for biliary calculi. By means of this procedure the shadow of the spleen was successfully projected on the fluoroscopic screen and the outlines of the organ were shown with the existing changes in configuration.

In 1914, in this country, W. H. Lockett and William H. Stewart demonstrated röntgenographically the ventricles of the brain in a case of fractured skull where air had invaded the interior. In this connection it is interesting to note that ventriculography in the form of air injection into the cerebral ventricles, followed by X-ray examination, has been recently carried out by W. E. Dandy, who describes the method as invaluable in internal hydrocephalus and of great practical value in the diagnosis and localization of many intracranial conditions. He points out that the outlines of the lateral cerebral ventricles can be sharply outlined by the Röntgen ray if air is substituted for cerebrospinal fluid. This injection of air into the ventricles had no deleterious effects in twenty children between six months and twelve years of age.

After this experience and a careful study of the new method we decided to give the matter a fair trial in order to satisfy ourselves whether by improving on the technic we might show distinctly the parenchymatous organs in themselves as well as in their relation to each other and any pathological changes which might be present in these organs.

The simple method employed by us is as follows: After the patient is prepared in the usual manner for Röntgen examination (thorough cleaning out of the bowels and emptying of the bladder) he is put flat upon his back and the abdomen is then inflated with about three to four litres of oxygen. The whole outfit required for this procedure consists of an oxygen tank to which is attached a rubber bag (such as is used with the gas-oxygen apparatus for anæsthesia) with a capacity of about one gallon or four litres. To this bag is attached a small rubber tube which can be easily connected

with a regular lumbar-puncture needle. The spot where the needle is to be inserted is sterilized with iodine and the skin rendered insensate by an injection of novocain-adrenalin solution. The spot from which in our judgment it is easiest to inflate the abdomen is two to three fingers to the left of the umbilicus and about one and a half inches below it. This procedure is very simple. Anyone who has had surgical experience can easily gauge the thickness of the abdominal wall. Our practice is to push the needle to a point where it touches the fascia; then we stop for one or two seconds. After that the needle is pushed through fascia, muscle and peritoneum without any difficulty. The plug is then removed from the needle and the needle is connected with the rubber tube. A slight pressure on the bag will now inflate the abdomen with oxygen. As a rule, this takes between four and five minutes and the amount of oxygen to be introduced varies between three and four litres or nearly one gallon. When the abdomen is entirely distended the patient usually complains of a sensation of fullness and slight pains in the shoulders (the latter apparently due to pressure against the diaphragm). As far as the fate of the oxygen is concerned, it is usually absorbed without any trouble within twenty-four hours.

The procedure necessarily stands and falls with the safety of the peritoneal inflation with oxygen. Reliable evidence in this respect is not wanting. Dr. W. S. Bainbridge of this city has used oxygen in intra-abdominal administration with uniformly favorable results in more than 125 laparotomies. The therapeutic method of oxygen injection into the peritoneal cavity with immediate closure of the abdomen and gradual absorption of the gas was first employed by him in 1903 and reported in 1908 and 1909. Godwin, in England, on the basis of four years' favorable experience recommends intraperitoneal injections of oxygen during and after abdominal operations. Both these writers endorse the employment of the method after removal of large tumors to overcome negative abdominal pressure, for the prevention of primary or recurrent adhesions, in tubercular peritonitis, and in general septic peritonitis. Far from being in the least injurious, oxygen in the abdominal cavity has been found to lessen post-operative shock, nausea and vomiting. The gas is non-irritative to the peritoneum and the abdominal organs.

Now a few words about the apparent danger of puncturing the intestines. Experience has shown us that the elasticity of the intestines permits them to recede before a sharp intruding body such as a needle, provided that caution is used and the needle advanced slowly. We ourselves have encountered no difficulties in this respect and have experienced no untoward effects. Our experience has been absolutely in accordance with the findings of other writers mentioned in this paper.

Within two to three hours after inflation the patient should be referred to the röntgenologist. This method permits the Röntgen examination to be made in the most varied positions, standing or lying down, and all of the

OXYGEN PERITONEAL INFLATION BEFORE X-RAY

solid organs are revealed with a clearness and distinctness heretofore impossible to attain.

For example, in the erect position, due to the fact that oxygen always rises to the highest point, we were able to secure beautifully contrasting röntgenograms of the diaphragm, liver and in many instances the gall-bladder attacked, normal spleen with its outstanding pedicle and both kidneys.

In the horizontal position, with the patient's back to the table, we were able to demonstrate some very marked post-operative adhesions between the intestines and the parietal peritoneum. We also demonstrated with great clearness a large carcinoma of the ascending colon.

In the exaggerated, lateral, Trendelenburg position (patient lying on either the left or right side in the bayonet position) we were able to demonstrate not only the normal uterus with its round ligaments, small cystic ovaries and normal bladder but also myomatous tumors of the uterus, which, as is well known, have not heretofore been röntgenographically demonstrated.

Pathological conditions, such as carcinomatosis, cirrhosis or marked hypertrophy of the liver, enlargement of the spleen and tumors of the stomach and intestines, as well as those of the genital organs, are now easily demonstrated. The procedure which we are presenting on the basis of its obvious merits promises a wide extension of the diagnostic scope of the Röntgen rays in the domain of gynæcological and general abdominal surgery.

In concluding this short report we would like to say that in our opinion this procedure is not a competitor of the opaque meal method, as the latter concerns the hollow organs of the abdomen, whereas our method is concerned mainly with the parenchymatous abdominal organs. We therefore believe that it will be a great help in the Röntgen diagnosis of the abdominal organs when used in combination with the barium meal.

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NEW INSTRUMENTS FOR PROCURING AND PREPARING AUTO-GENOUS BONE BOLTS AND KEYS AND SPECIAL METHODS OF THEIR APPLICATION IN SHAFT FRACTURES

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For the purpose of this discussion but three methods of fixation will be described.

For the performance of the simple technic involved, one right-angled motor nose (Plate 3) controls and transmits power to the instruments illustrated in addition to practically all types of rotary cutters.

The method of applying power to this rotary adjustable cross nose will be discussed later in another article if deemed worthy. The devices for this power chuck or nose consist of four cylindrical core drill saws, numbered 1, 2, 3, 4, Plate 1. Two rotary cutters (end mills) numbered 5 and 6, Plate 1; a buried saw or "submarine" cutter, Plate 5; conventional circular saws and a set of three forceps; one locking forceps for each side of the fracture, and an extensor or spreader forceps resting in projections on the locking forceps as shown in Plates 1-6.

Operation 1.—The tibia. Where not too comminuted or excessively oblique, the spine of the tibia is incised with fine hand saw or more quickly by circular saw, Fig. 1 (Plate 2). Saw cut made across base of peg just deep enough to join longitudinal saw cuts and for the *width* of peg base only. The bone should not be weakened by a cross cut long and deep enough to completely free the peg. With this saw cut as a guide a few thrusts of a small drill, as in Fig. 2 (Plate 2), completely free the peg. Drill is shouldered as shown in illustration to limit its depth. This method has proved much more accurate, quicker and better in every way than any sort of chisel. A similar cut is made in the opposing fragment, half as long and the key freed in the same manner.

The tibial spines now present trough-shaped slots which are shaped convexly by inserting rotary concave end mill No. 5 (Plate 1) in the manner drawn in Fig. 3 (Plate 2). The sliding key is now grooved on opposite sides by rotary bit No. 6 (Plate 1) and Fig. 4 (Plate 2). Key is now rotated until upper flat surface is practically horizontal and slipped back into slot from which it came, Fig. 5 (Plate 2). Fractured ends now approximated so that slots are directly continuous and concave key is thrust across half its length, Fig. 6 (Plate 2). It will be seen that this key lies on edge before removal and when replaced has been rotated about 45 degrees on its long axis. The mathematics is such that through this rotation the peg *after* shaping fills snugly the space from which it was cut.

It is evident that this operation quite firmly fixes the fracture against rotation, angulation and side slipping. The practical results substantiate

the theory and in suitable cases the fixation has been found quite rigid, yet if properly done to allow just enough limited motion to prevent splitting or snapping.

Tight autogenous work imposes too much pressure on surrounding bone and creates a tendency to snapping in key or dowel. Peri- and endosteum remain intact upon this key, and the medullary canal remains patulous. The operation requires no second incision, and may often be accomplished with ease through a one line linear incision favoring better nourished skin. The depressed position of the locking key in the completed work at this point facilitates wound closure without suture pressure. The rather abrupt notches at either end of tibia slots should be rounded with a few saw thrusts before closing. If a tibial transplant seems *absolutely* indicated in a femur this concave tibial key may be used in the femur with exactly the same technic and the key may be cut quite long if needed. The length of the key or inlay depends upon the coincidence of curves in femur and tibial crest and must be accurately measured by the surgeon's eye, for no two bones present sufficient accuracy to permit routine work.

Should the operator desire to have this tibial key fill the whole slot in the femur longitudinally, one side of the femur slot may be convexed with end mill and one side of key concaved. The ends of key are bevelled so that when key is rolled sidewise into femur slot its bevelled ends prevent its sinking below the level of surrounding bone. Two holes are now drilled and tapped between key and femur on the ungrooved side and two threaded pegs screwed home. This produces a very firm locking inlay without extraneous material of any sort for fixation.

Operation 2.—The femur. The sliding dowel method. 1. Incision. 2. The easily elevated fragment is grasped with locking forceps about $2\frac{1}{2}$ inches from its end; forceps locked snugly and bone elevated about half its diameter. Cross nose armed with saw No. 4 (Plate 1) is now introduced and a dowel cut from bone *in situ*. Procedure illustrated in Plate 3. Peg loosened by cross drilling as before. Peg removed. Bone end now appears as in Plate 4. At this juncture if the opposed underlying fragment may be elevated by opposite locking forceps until approachable from the end, the next smaller saw, No. 3 (Plate 1), is used to cut the counter bore opposite the original dowel but half as long. Peg from this counter bore similarly removed. If at this stage the underlying fragment may only be elevated to the level of its fellow and not above without undue trauma, an instrument is brought into use (Plate 5). This instrument is adjustable around motor nose at any angle up to about 280 degrees, and is small enough to be backed in flush with the bore made in first fractured end. It is always possible to bring fractured ends level. After this instrument is submerged in the original bore as shown partly entered in Plate 5, the fractured ends are aligned, power applied, and the buried saw or "submarine" slipped across, thus cutting the counter opening in accurate

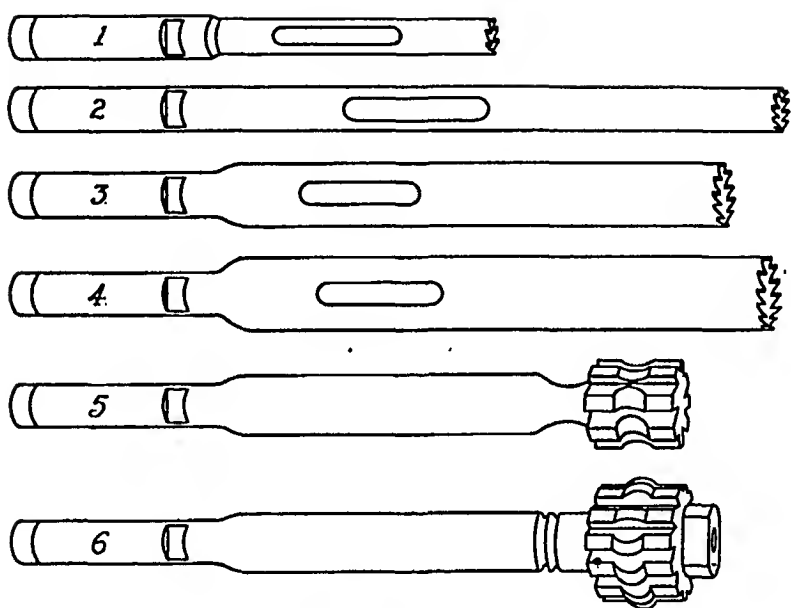


Plate 1.

Fig. 1.

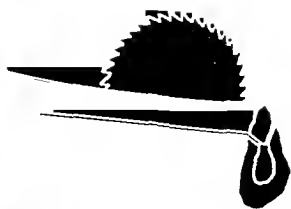


Fig. 3.



Fig. 2.

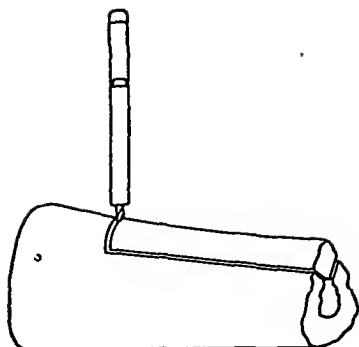


Fig. 4.

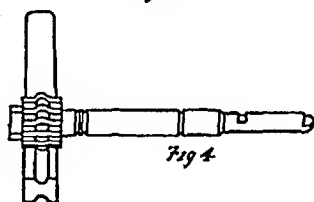


Fig. 5.

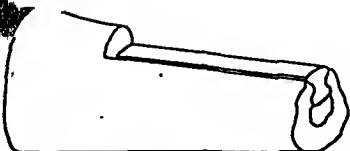


Fig. 6.

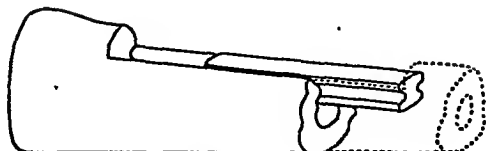
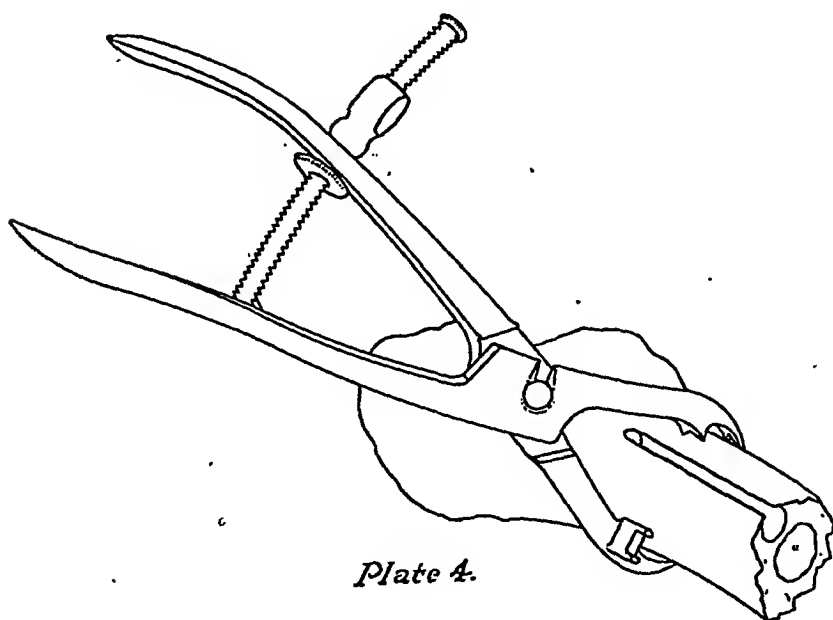
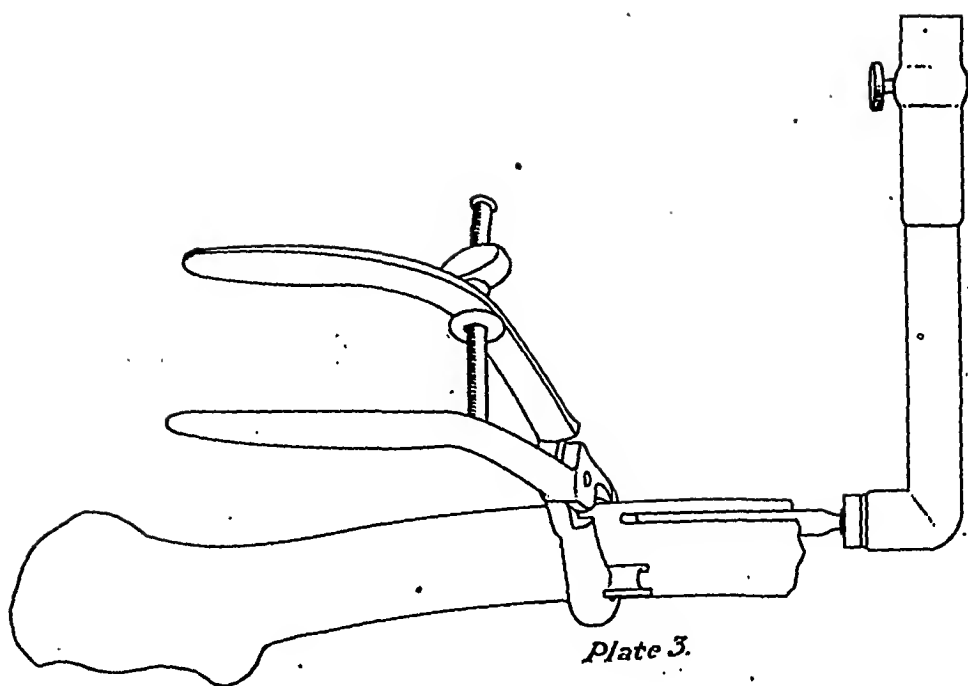


Plate 2.



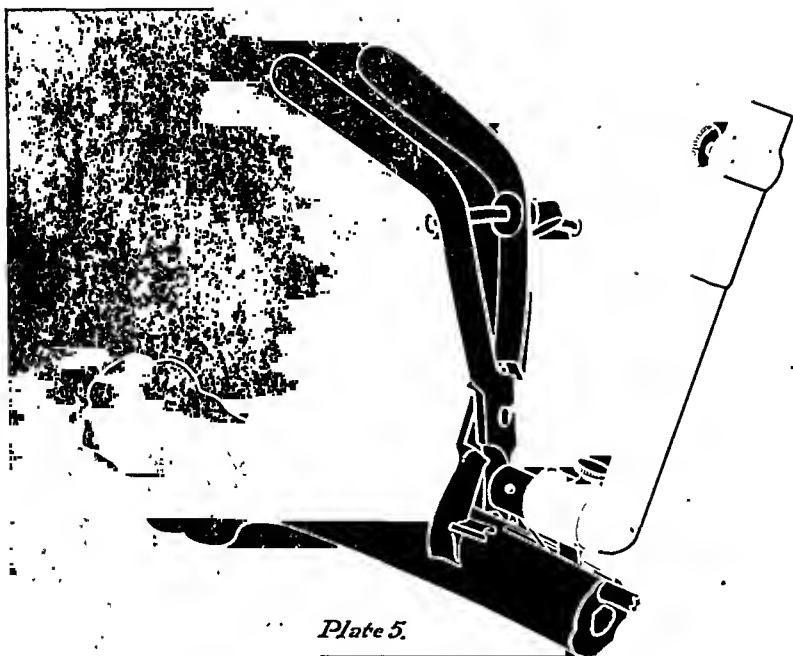


Plate 5.

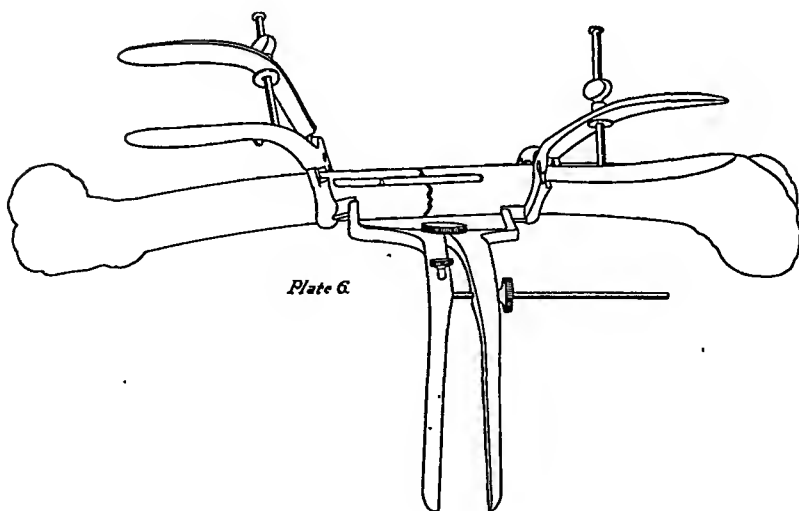


Plate 6.

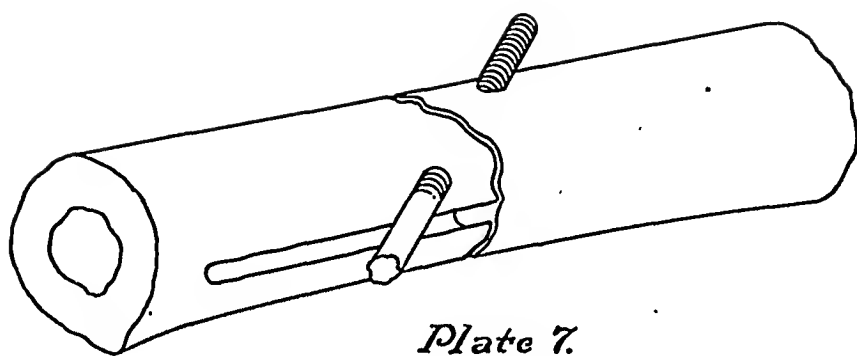
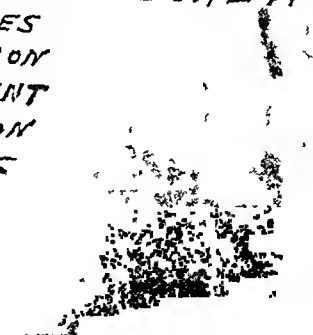


Plate 7.

CASE - ONE
PLATE - ONE

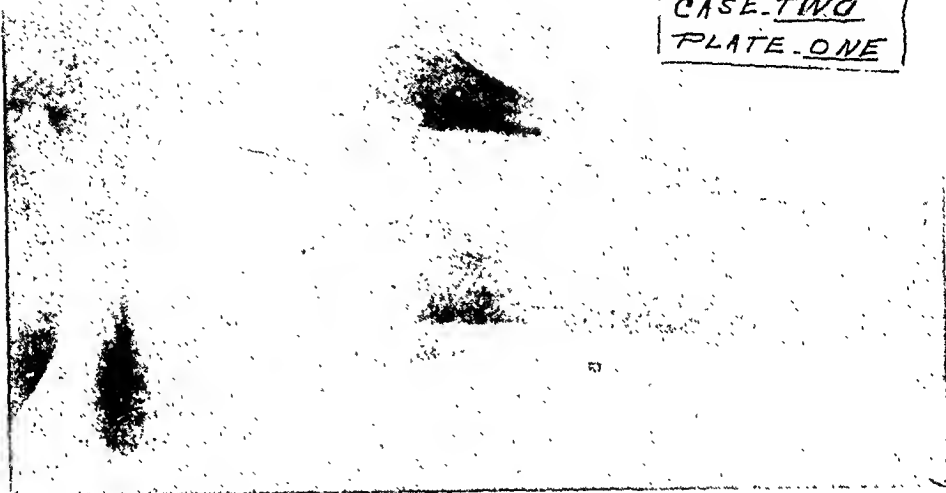
TIBIA OPERATED 1912
AUTOGENOUS CROSS SECTION
SUBSEQUENT PICTURES
LOST PRIMARY UNION
CORRECT ALIGNMENT
PERFECT FUNCTION
SEEN TWO YEARS
AFTER
OPERATION



TWO INCHES SHORTENING R TIBIA
UPPER FRAGMENT SPLINTERED
INNER SIDE

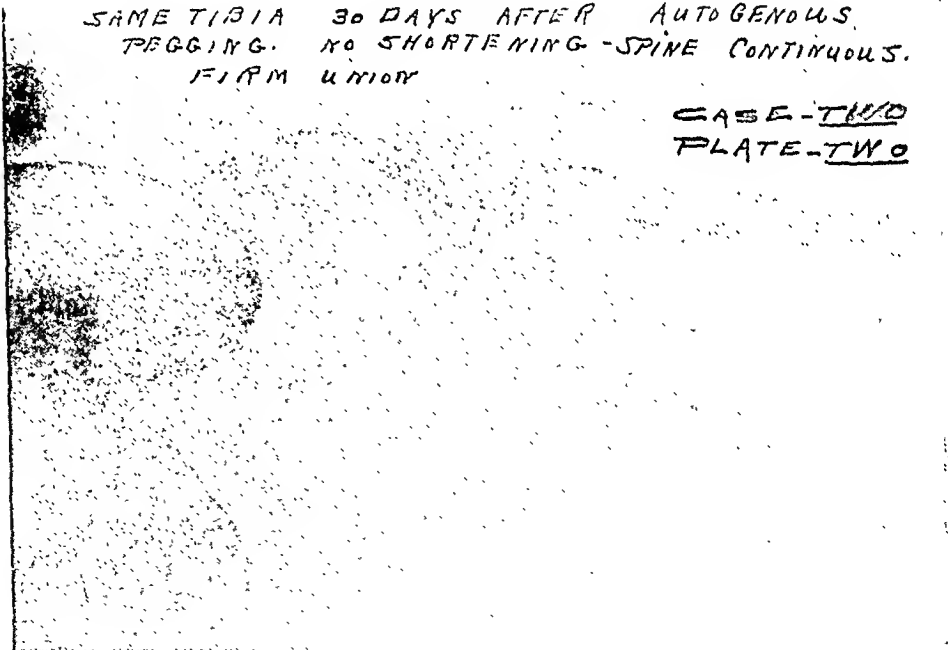
OPERATED - 1917 -

CASE-TWO
PLATE-ONE

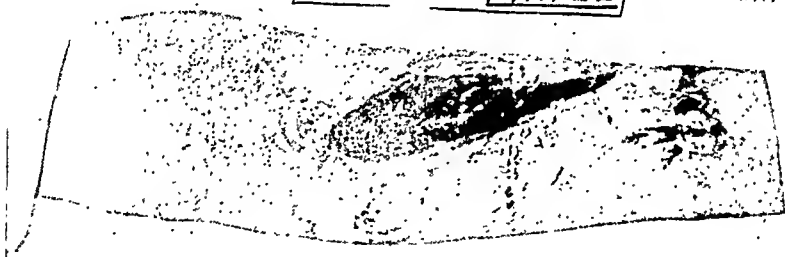


SAME TIBIA 30 DAYS AFTER AUTOGENOUS
PEGGING. NO SHORTENING - SPINE CONTINUOUS.
FIRM UNION

CASE-TWO
PLATE-TWO



SAME TIBIA SOFT TISSUES AFTER 40 DAYS
BONE FIRM- MUSCLES AND SKIN SLOWLY
HEALING END RESULT ABSOLUTE EXCEPT
FOR SCARRING, FROM BADLY CONTUSED AND
LACERATED
CASE - TWO
PLATE - THREE SOFT PARTS.



alignment and position. Saw now slipped back in original bore, lower fragment depressed and "submarine" removed. Motor and attachments are now put aside. Long dowel is now replaced in the bore from which it came, bone ends brought in alignment and dowel slipped across half its length.

Finished bone with forceps in place shown in Plate 6. Forceps now quickly removed by three slight turns of locking nuts beginning with middle or extensor forceps. Should it be desired to reinforce this splinting, the short peg from counter bore may be threaded and screwed across the fracture, above the sliding dowel in the manner illustrated in Plate 7. The details of this threaded peg will be touched upon in the next operations.

3. Threaded autogenous pegs. The dowels for these threaded bone screws are taken from the fractured bone, by an end approach, *in situ* and practically in one motion, as illustrated and described (Plate 3).

For cross bolting oblique or spiral fractures and in cancellous bones, necks, tuberosities, condyles, the uses and adaptations are myriad and in many cases most gratifying. Wherever possible in shaft bones, the bolt should be placed tangentially as illustrated in Plate 7. This gives more continuous support to the bolt and an infinitely stronger result.

In spiral and oblique tibial fractures are these bolts particularly useful and easily and quickly applied.

Four cases are illustrated.

CASE I, in 1912, shows a suitable fracture of the tibia for either Method 1 or for threaded autogenous bolts. This was bolted.

CASE II illustrates a fracture high on the tibia which held nicely with a large dowel. CASES III and IV kindly illustrated and described by Dr. M. L. Emerson as a most helpful portion of this article illustrate two compound comminuted tibias operated by us. These bolts naturally are trimmed off flush and smooth and leave no rough projections or irritating spicules. In the tibia particularly is this simplicity welcome, for in many cases such apposition cannot be had with wire or even with several plates, and metal screws and bolts necessarily leave projecting heads which in this position particularly are undesirable.

Preparation of compound cases. For twelve years I have treated compound fractures by surrounding the foot (if a leg) in an alcohol compress and tying over this a sterile rubber bag. The leg with the foot now excluded is thoroughly immersed or irrigated for one hour with a fairly strong solution of zinc permanganate or potassium. Early and very early operation seems to be more widespread; in all cases this has been routine with me, and, in view of the uniformly happy results even with plates, I am led to the belief that such treatment negligibly retards bone growth if at all—and the fact is self-evident that gentle extrusion of fractured ends and gentle opening of the traumatized area with thorough submersion or irrigation and removal of free spicules and long unnourished shreds, gives

access to our bacterial inhibiting solutions, and I shall believe that no mere skin preparation or dabbing around with sponges of picric, or iodine or all of them will effectually reach the intricate recesses of our mangled wounds, nor the spongy microscopic surfaces of our bone ends.

I take pleasure in expressing my gratitude for the great help and encouragement shown me by Dr. S. H. Buteau, Dr. M. L. Emerson, Dr. Theo. Olmstead and Dr. W. E. Mitchell, of Oakland, Professor H. M. Evans, of the University of California, Professor F. E. Blaisdell, of Stanford University, and Dr. G. A. Weyer, of San Francisco.

NOTE ON THE USE OF AUTOGENOUS BONE GRAFTS, SECURED AND APPLIED AFTER THE METHOD OF BELL

By MARK LEWIS EMERSON, M.D.

OF OAKLAND, CAL.

It has been demonstrated that if our operative technic is correct, we can approach bone tissue with the same degree of confidence that we can any other tissue of the body. The manner of approach to the great variety of bone lesions is far from being settled. The Albee cortical graft, the intermedullary graft extensively used and advised by Davison and Smith, and more recently the Bell graft, seem to offer the most promising results. The Albee graft is often taken from another bone, or is held in place by chromic gut or kangaroo tendon, and of itself is not supposed to act as a fixation splint, as it will fracture under strain. The intermedullary graft is not a true graft, as it is more of a bone plug, wherein compact bony tissue is placed in the medullary cavity, thereby supporting the fragments while union takes place. The Bell graft brings compact tissue to compact tissue; it is a true graft as well as a splendid mechanical support. It takes the graft from the site of fracture or from the fragments. There is generally plenty of graft material at hand; one or a half dozen grafts several inches long can be obtained from the average fracture in long bones, and these can be applied to prevent misalignment and rotation according to the mechanical ingenuity of the operator. No suturing or fixing of the grafts is necessary, as they mechanically fix themselves.

Associated with Doctors Bell and W. E. Mitchell we have been using the necessary material offered for this type of bone work at the anatomical laboratory of the University of California, where we have attempted the mechanical fixation of various types of difficult fractures presented at Merritt Hospital, by the Bell method. X-ray prints of fractures were taken, and by the aid of hand and motor saws and chisels the fractures were reproduced on the cadaver. The grafts were then made and applied and various tests given as to the strength of the grafts and their ability to maintain the fragments in place after a certain amount of strain and traumatism. A more technical description of these tests, as well as the application of the Bell graft to the more complicated fractures, will be the subject of another paper.

Whether the keel of the tibia is used for an Albee graft or a section of the fibula for a medullary dowel, this of itself is quite a procedure, as this often takes half of the operative time, and is occasionally followed by complications, such as fracture of the tibia, periostitis and infection. This latter procedure is eliminated in the great majority of cases treated

by the Bell method, and I present for your examination sections of the long bones, so that you may observe the extent of the compact tissue. If the graft itself contains 60 per cent. of compact tissue and is placed within 60 per cent. of compact tissue, it is sufficient for its use, as the cancellous tissue in close proximity of the compact tissue has a certain valuable strength for this type of work. The living cancellous tissue is capable of holding a thread, but a peg entirely of cancellous tissue is of itself too weak. There may be certain value in cancellous bone from a physiological standpoint; it is absorbed and replaced quicker than compact bone. Its value as a filler for cavities, dead spaces and ununited fractures is being worked out by certain operators. V-shaped pieces of semicancellous bone taken from the great trochanter of the femur or tuberosities of the tibia and placed between the ununited fracture of the neck of the femur, is a feature used instead of the Albee peg of compact tissue taken from the tibia. Reconstruction work about the face, or a templet of the lower jaw made out of one or two ribs, could be easily constructed by the Bell method. As a general rule all the graft necessary can be taken from the end of either fragment at the site of fracture.

The small bones of the forearm, when both are fractured and displaced, can be readily held in place by this method as well as in clavicle. Os calcis, astragalus, patella, sacro-iliac joint and displaced tuberosities, have all been experimented upon with apparently ideal results, in the anatomical laboratory.

THE TREATMENT OF ACUTE GASTROMESENERIC ILEUS

BY ALBERT PAUL CONDON, M.D.

OF OMAHA, NEB.

GASTROMESENERIC ileus is an obstruction of the upper part of the gastro-intestinal tract due to a compression of the terminal duodenum. This compression is brought about by the small intestines sagging into the pelvis, producing a pull upon the root of the mesentery, this in turn compressing the duodenum so that its lumen becomes obliterated. The passage of duodenal contents is stopped, but the circulation of the bowel rarely, if ever, is interfered with.

I am aware that there are other conditions in which there is a dilatation of the stomach, in which the compression by the mesentery of the small intestines is not the cause. But, in this paper I am confining my remarks to that distinct morbid entity in which the duodenum is compressed by the root of the mesentery of the small intestines.

Much has been written in the past twenty years in regard to dilatation of the stomach occurring under various conditions, and the controversy has been heated as to what part the mesenteric pull plays in causing this condition, if any.

I do not know what percentage of the instances of postoperative dilated stomach is due to this gastromesenteric pull, or how much to other conditions, but I do know that a pull upon the mesentery is a frequent cause, as I have on six different occasions, four times at operation and two at autopsy, found the duodenum firmly compressed and its lumen obliterated by the root of the mesentery. In all the patients I have operated or seen at autopsy the stomach and duodenum were greatly dilated, the intestines below the obstruction empty and having the appearance usually found distal to an obstruction.

Clinically, one can usually differentiate a gastromesenteric ileus and a dilated stomach from other causes. The most important differential point is, that in a gastromesenteric ileus the distention is in the stomach and duodenum, the rest of the intestines being collapsed, so that a gastric lavage not only reduces all of the distention, but renders the abdomen scaphoid.

When there is a dilated stomach due to disturbed innervation or other causes, one gets more or less distention of all the intestines. A gastric lavage will reduce the distention some, but not entirely, and the coils of small intestines can usually be made out against the abdominal wall.

Rokitansky, the Vienna pathologist, in 1842, was probably the first to describe gastromesenteric ileus and to give as the cause the constriction of the duodenum by the root of the mesentery.

This condition is usually thought to occur more frequently after

abdominal operations, but our experience has been that it happens just about as often following other operations and in diseases requiring long confinement in bed. We have seen several instances of gastromesenteric ileus after kidney fixation, one after amputation of the leg, one following a mastoid operation. We have also observed it in two patients who had had no operation.

This form of obstruction is noticed frequently in a slight degree, producing just a partial occlusion, giving rise to the so-called chronic gastromesenteric ileus, for which several operations have been tried with success. I might just mention the resection of the ascending colon, and duodenojejunostomy.

Acute gastromesenteric ileus is a complete obstruction and, unless promptly relieved, ends fatally. We are all aware that the higher up in gastro-intestinal tract the obstruction is situated the quicker death ensues, due to the reabsorption of poisons secreted by the patient himself.

Death usually occurs in from thirty-six hours to three days, following obstruction in the duodenum or upper part of the jejunum. On the other hand, I have seen patients with a complete obstruction of the large intestine in good shape after ten days' time. Before we began the use of the treatment that I am going to describe, this form of ileus was our most dreaded postoperative complication.

Five years ago Newell reported, before the Douglas County Medical Society, the postoperative deaths occurring in the Nicholas Senn Hospital for one year. There were 16 deaths and 3 of these were due to gastromesenteric ileus. One we recognized only at autopsy. She had not vomited and was distended very little. The other two were operated upon after failure of frequent lavage and change of position. Both were deeply intoxicated and promptly died.

It is not my intention to discuss the various phases of this disease about which much has been written in recent years. I simply wish to call attention to a method of treatment which has been life saving in our hands and the application of which is simple and rational and in no way harmful.

The usual treatment recommended in this form of acute ileus is: frequent lavage of the stomach and postural methods with a view to altering the position of the intestines, thereby releasing the pull upon the mesentery. If these do not give relief then opening the abdomen and lifting the intestines out of the pelvis and in some cases doing a duodenostomy or duodenojejunostomy.

The postural methods, such as elevating the foot of the bed, etc., we have found of little value, owing to the fact that the peritoneal cavity is a potential one and the change of position does not relieve, to any marked extent, the pull on the mesentery. We had thought of making the peritoneal cavity an absolute instead of a potential one by injecting air into it, thereby making it easier to change the position of the intestines

TREATMENT OF ACUTE GASTROMESENTERIC ILEUS

by elevating the pelvis, but we came to the conclusion that this would not be nearly as efficacious as injecting some fluid intra-abdominally, and then placing the patient in a sitting position. This fluid would then gravitate into the pelvis and displace the intestines upward, and thereby relieve the pull on the mesentery.

This method of treatment occurred to me while operating upon a patient for an intestinal obstruction January 12, 1915. She had the usual signs and symptoms of an ileus when I saw her, twenty-four hours after onset. Upon opening the abdomen the stomach was found enormously dilated, filling the entire abdominal cavity. Elevating the stomach, I found the obstruction to be due to the small intestines being jammed into the true pelvis, pulling upon the mesentery and shutting off the duodenum. After releasing the pull a crease could be seen on the duodenum.

The question then came up how to prevent the intestines from again entering the pelvis and reproducing the obstruction. I thought that by pouring water into the abdomen and filling the pelvis would prevent the possibility of the intestines falling in again, which I did. I then realized that I could have gotten the same results in this patient by injecting a fluid into the peritoneal cavity without having opened the abdomen. I closed the abdomen and emptied the stomach by a gastric tube. She made an uneventful recovery. She continued to occasionally have attacks of a mild degree of obstruction.

On February 6, 1919, a radiographic examination showed a dilatation of the duodenum. I opened the abdomen and found the stomach somewhat enlarged, the duodenum as large as my arm. A duodenojejunostomy was done and she has been well since. I believe in such chronic cases this to be the operation of choice.

Since January, 1915, we have had in the Nicholas Senn Hospital eight well-marked cases of postoperative gastromesenteric ileus, in which the diagnosis was clear. In each case the stomach lavage was resorted to every few hours, and after several washings with no abatement of symptoms the injection of Ringer's solution into the peritoneal cavity was made. Several of these patients were deeply intoxicated. We used from 2000 to 3500 c.c. of the solution and in each instance all of the symptoms were promptly relieved.

In the last case that we had, about two months ago, following a gall-bladder resection, the symptoms were relieved after one injection. They recurred again, however, in three days' time, and we gave a second injection, adding to the 2500 c.c. of Ringer's solution 500 c.c. of glucose, which prevents its rapid absorption.

I think it might be a good plan to add the glucose as a routine measure to prevent the too rapid absorption of the fluid and to help combat the acidosis that is present in these patients.

The technic of the treatment is simple, the instruments necessary are such as are used in an ordinary hypodermoclysis. We make the

point of injection in the midline below the umbilicus, but if an incision has been made here, so that adhesions may be feared, any part of the abdomen may be used.

A small amount of local anæsthesia is injected at the site where the fluid is to be introduced. A medium-sized needle should be selected to make the injection. I use a needle commonly employed for lumbar puncture. It is slowly passed through the abdominal wall by a rotary motion, having the fluid in the needle under some pressure, so if the intestines are against the abdominal wall they will be pushed away by the fluid as the needle enters.

We have found that patients tolerate from 2000 to 3500 c.c. of the liquid before they have distress. After the amount of fluid necessary is injected before removing the needle we inject a few 100 c.c. of air; this latter renders the peritoneal cavity an absolute instead of a potential one, facilitating a change of position of the intestines. We consider such an injection into the peritoneal cavity to be devoid of danger, so much so, that on a number of occasions have used this method to administer physiologic saline solution in preference to giving it subcutaneously or intravenously.

After the injection the patient is placed in as near a sitting position as possible and the stomach lavage continued about every three hours until the stomach secretions become normal.

In conclusion, if we are correct in our conception of the etiology of an acute gastromesenteric ileus, then we are able, by a simple and harmless method to relieve this most dangerous condition of obstruction for a certainty by injecting enough fluid into the abdominal cavity and placing the patient in such a position that it will gravitate into the pelvis. The small intestines must become displaced upwards and thereby relieve the pressure upon the duodenum.

THE NO-FLAP OR GUILLOTINE AMPUTATION *

AN UNFORTUNATE RESURRECTION

By JOHN H. GIBBON, M.D.

OF PHILADELPHIA

WHAT I have to say in this brief communication is well epitomized in the title. The method of simply making a circular amputation of an extremity, dividing all the structures, skin, muscle and bone, at the same level, is a resurrection, and what I have seen after these amputations, the frequent secondary hemorrhages, the slow healing extending over months, the painful dressings and the secondary operations which are necessary in nearly all of them, cause me to designate the resurrection as unfortunate.

My first sight of these stumps was at a British base hospital, where we had them in great numbers, and where we were obliged to operate often for secondary hemorrhage, usually from the femoral artery. Repeated hemorrhages occurred in a number of thigh amputations necessitating ligation of the common femoral in many instances.

In spite of the constant irrigation of the wound with solutions, the adherence of the gauze to the raw surfaces, and especially to the exposed nerves, made the dressing for a number of weeks an extremely painful procedure, notwithstanding the fortitude of the British Tommy. All kinds of devices were used to prevent this sticking of the dressings and thus lessen the pain, but none was very successful until the surface had become well covered with granulation tissue.

The application of appliances to draw down the skin, which had already in most instances become fixed at the edges, was itself a painful and troublesome procedure and too often did not succeed sufficiently to obviate the performance of a secondary amputation or a plastic operation.

Because of these dangers and difficulties, it would seem that there must have been some very strong reasons to justify this type of amputation. The justification seemed to rest on these two reasons: that it was life saving, because it was quickly done, especially in the cases of gas gangrene, which was the common cause of amputation in this war, and that it gave a good stump for an artificial limb. For these reasons this method of amputation became quite universal in France, and yet I do not think either or both justified the practice because of the complications already enumerated, and I believe I did and saw enough amputations later where a skin flap was made and reflected to an extent that fully exposed the divided muscles, and where healing was fairly prompt and a good conical stump formed, to prove that the guillotine amputation had no place, or a very limited place, in war surgery. It may be said that the reflected flap method does not obviate the painful dressings and the secondary hemorrhages; but this is not true, for in every

* Read before the American Surgical Association, June 16, 1919.

instance where prompt evacuation or death did not occur, the wound had become sufficiently clean in from four to ten days to permit the bringing down of the flaps, and I can recall no case of secondary hemorrhage after the sterilization of the stump and the approximation of the flaps. The hemorrhages which I saw in the cases of guillotine amputation occurred after the tenth day. The making and the reflection of the flaps occupies but a few minutes and cannot greatly increase the shock. A circular suture passed around the ligated stump of the vessels buries it sufficiently to insure against early hemorrhage. If the flaps are properly reflected, the wound is as wide open as in the guillotine amputation. I employed these reflected flaps in a number of thigh amputations for gas gangrene, first at a British base and later at a Casualty Clearing Station, and in a large part of the American sector still later this method became the rule. My opinion then is not based on theory, but on experience with both types of operation, and it is very fixed that the no-flap amputation is an unfortunate resurrection.

But I have said nothing of the second reason for doing the no-flap operation: namely, that it gives a better stump for the wearing of an artificial leg. All I have to say is that the reflected skin flap amputation gives exactly the same type of stump, but gives it earlier, with less suffering and less danger and, that if it does not, then we must employ the guillotine method in civil practice.

Are we prepared to do it?

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held March 13, 1919

DR. G. G. ROSS, Acting-President, in the Chair

SEPARATION OF THE LOWER EPIPHYSIS OF THE FEMUR

DR. HENRY R. WHARTON reported three cases in which the lower epiphysis of the femur had been separated, as follows:

CASE I.—John W., thirteen years of age, was admitted to the Presbyterian Hospital, July 1, 1913, having, twenty-four hours before, fallen from a wagon, injuring the right knee. He was seen by a local physician, who attempted to reduce the deformity at the right knee, under an anæsthetic, but failed. When seen shortly after admission, the region of the right knee was much swollen, and the deformity presented was that of an anterior dislocation of the knee-joint. The joint was fixed in a position of slight flexion, the head of the tibia and epiphysis of the femur being in front of and above the lower end of the shaft of the femur. X-ray examination showed a separation of the lower epiphysis of the femur, the head of the tibia, with attached epiphysis, being in front of the lower end of the femur.

Two attempts, under anæsthesia, were made to reduce the displaced epiphysis without success. The displaced epiphysis then was exposed by a lateral incision on the outer aspect of the knee; this later was supplemented by one on the inner side. A large amount of blood-clot was exposed in the tissues around the seat of injury. By extension and flexion of the knee and the use of an elevator, the epiphysal fragment was with great difficulty restored to its normal position. Fearing a recurrence of the deformity the epiphysis was secured to the diaphysis by a heavy silver wire suture. The wounds were closed without drainage and the limb secured in a posterior splint. Infection of the wound occurred, which required opening of the wound and drainage.

Some days after the reduction had been accomplished it was noticed that the patient had foot-drop, evidently from contusion of the external popliteal nerve. The patient's convalescence was slow, by reason of the wound infection, but he made a good recovery, and when last examined, some three months after the injury, had good motion in knee-joint, aside from slight restriction in flexion. The foot-drop had entirely disappeared.

In this case the reporter said that it was an error to have closed the wounds without drainage, in view of the large amount of blood-clot deposited in the tissues and the contusion of the parts. Fixation of the epiphysis to the diaphysis by suture was unnecessary, as in these cases, when the deformity has been reduced, there is little tendency to its reproduction.

CASE II.—H. D., six years of age, fell down an iron stairway on the Pennsylvania Railroad, and was admitted to the Presbyterian Hospital, March 13, 1918, a short time after the accident. He presented then marked swelling and deformity of the right knee, which on examination proved to be a separation of the lower epiphysis of the right femur, with anterior displacement of the epiphysis and attached head of the tibia. X-ray examination confirmed this diagnosis. The patient was given an anæsthetic, and after somewhat prolonged manipulation the deformity was overcome and the epiphysis restored to its normal position. A moulded binder's board splint was applied to the limb, which extended from the foot to the groin, and in a week, when the swelling had subsided, a plaster-of-Paris splint was applied. The splint was retained for six weeks. After this time passive motion of the knee-joint was practised, and the patient was soon walking without difficulty.

CASE III.—T. G., sixteen years of age, was admitted to the Presbyterian Hospital, July 4, 1918, having a short time before been struck by an automobile, injuring the right knee. The right knee presented a very remarkable deformity. The leg and knee-joint appeared to be drawn inward, while the lower end of the femur above the knee projected outward and was covered by the tightly stretched skin. The rough transverse edge of the lower end of the femur could be felt just under the skin, the injury evidently being an inward lateral displacement of the lower epiphysis of the femur. An X-ray examination showed this to be an inward displacement of the lower epiphysis of the femur, with a limited oblique fracture of the inner edge of the shaft of the femur.

Under anæsthesia by manipulation a fair reduction of the displaced epiphysis was effected. A binder's board splint was applied, extending from the foot to the upper part of the thigh, and when the swelling had subsided at the end of a week, a plaster-of-Paris bandage was substituted. Fixation of the limb was kept up for six weeks, and after this time passive motion was practised, and the patient was encouraged to use the limb. When seen two months after the accident, he had good motion of the right knee-joint.

Doctor Wharton, in commenting on these cases, said that these three cases of simple separation of the lower epiphysis of the femur are the only examples of this injury that have come under his observation. He had seen a number of cases of compound separation of the lower epiphysis of the femur in which the lower end of the femur lacerated the soft tissues, sometimes the great vessels, and was driven through

the skin. These cases occurred in pre-antiseptic days, and were promptly treated by amputation of the thigh. As he recalled it, the accident usually was observed in boys, who, in attempting to jump on a moving wagon, had the limb caught between the spokes of a revolving wheel. He had no doubt that in these cases at the present time, if the great vessels were not injured, under modern methods of treatment it would have been possible to have had recovery with a useful limb. In all of these cases he had been impressed with the great difficulty in reduction of the displaced epiphysis. In the first case, in which several attempts were made, open operation was resorted to, and even here reduction was very difficult. In examining the X-ray plates for Cases II and III it will be noticed that the reduction of the epiphysis in each case is not perfect, but the functional results are normal.

DR. A. BRUCE GILL raised the question as to the subsequent growth of the bone in cases of separation of the epiphysis in young children. Doctor Haas of San Francisco has published a series of papers on injuries of the epiphysis in relation to the aftergrowth of the bone, claiming that the growth of the bone will be retarded in certain instances. He himself had never seen these cases long enough to know whether separation of the epiphysis in growing children interferes with the development of the bone. In cases of osteomyelitis of the lower end of the radius he had seen deformity develop as the result of defective growth, and likewise in osteomyelitis of the lower end of the tibia.

DR. HENRY R. WHARTON, replying to Doctor Gill's question, said that in quite a number of epiphysial separations in children he had not seen much interference with the subsequent growth of the bone. He had seen some cases in which the epiphyses had been destroyed by osteomyelitis and in these there was marked deformity.

MULTIPLE FRACTURE OF THE PELVIS WITH THYROID DISLOCATION, DISLOCATION OF THE RIGHT FEMUR, DISLOCATION OF LEFT ASTRAGALUS, COMPOUND FRACTURE OF RIGHT TIBIA, LACERATED WOUND OF THE LUMBAR REGIONS

DR. HENRY R. WHARTON reported the following case:

B. B., twenty-five years of age, a brakeman, was admitted to the Presbyterian Hospital on the night of June 28, 1918. He was caught under a moving freight car and sustained the following injuries: Fracture of a large portion of right ilium, fracture of the right ischium, separation of pubic symphysis, thyroid dislocation of head of right femur, compound dislocation of right astragalus, fracture in lower extremity of left tibia, extensive lacerated wound of skin fascia and muscles of the lumbar region.

The patient on admission was suffering from profound shock, so that temporary dressings only were applied. He was put upon

stimulating treatment, and the next morning still presented the symptoms of profound shock. As he had passed no urine, a catheter was introduced and bloody urine was evacuated. The possibility of rupture of the bladder was considered, but a second catheterization some hours later showed the urine was free from blood, so that the hæmaturia was probably due to contusion of the kidney. As it was considered that he might die at any minute, no attempt was made to reduce the dislocation.

On the third day after admission, as the patient had reacted somewhat, he was etherized and the dislocation of the femur was reduced by manipulation, also that of the left astragalus, and his fractures were dressed. The patient had a slow convalescence. The pelvic fractures were dressed with difficulty on account of the extensive wound in the lumbar region.

He was finally discharged from the hospital October 6, 1918, and is now able to walk quite well, although his gait has been changed by the deformity resulting from the pelvic fractures.

RHINOPHYMA

DR. JOHN H. GIBBON read a paper with the above title.

EMPHYEMA

DR. JOHN STEWART RODMAN read a paper detailing observations in empyema made at Camp Bowie, Texas, for which see page 49.

DR. JOHN H. GIBBON said that military experience has advanced surgery, especially in the surgery of joints and of the chest. There is nothing about which he could speak more enthusiastically than of the sterilization and closure of the pleural cavity by the use of Dakin's solution. The first discussion he had heard of this work was by Tuffier, who reported 26 cases of infection of the pleural cavity with only four due to pneumonia, the others being due to gunshot wounds. All were sterilized under Dakin's treatment and closed. This should answer any question concerning the efficacy of the Dakin treatment. If one can sterilize the chest cavity and close it regardless of a big dead space underneath, one can say that whatever has been used it is the right method. They found that a great many of these wounds did not need closure but closed themselves. Doctor Rodman did not refer to the fact that a certain proportion of wounds reopen. This does not mean, however, that the wound has not been sterile. They had had gunshot wounds reopen after having been closed for two or three weeks, but the fluid was absolutely sterile in every one. Local anæsthesia should be employed and if the technic is properly developed the operation is not a painful one. When hemorrhage occurs the Dakin's solution has not been properly used. The agent does not encourage hemorrhage. In the American evacuation hospitals they had many large open wounds, but secondary hemorrhage was unusual

UNILATERAL TUBERCULOSIS OF THE KIDNEY

because the cases were clean and had been sterilized by Dakin's solution. Secondary hemorrhage is the result of infection.

DR. D. L. DESPARD, in connection with the sterilizing power of Dakin's solution, reported a case of long standing, that of a man operated on for empyema eighteen or twenty months prior to coming under his care. The man had a persisting suppurating sinus into which a probe could be passed for six or seven inches; he also had a persistent daily rise in temperature from 99° to 100° every afternoon. The opening was small, but a rubber tube a quarter of an inch in diameter could be inserted into the bottom of the sinus, and the patient, being a druggist, made his own Dakin's solution and injected it himself. In a month the purulent discharge had ceased; the tube was kept in for a week or ten days longer and then removed. He has had no temperature for several weeks and apparently the cavity is entirely closed.

DOCTOR RODMAN said that notwithstanding anæsthesia is regarded as being unsafe in these cases, he had never been able to resect ribs without some pain, even if infiltration and anæsthesia with novocaine were carefully done and the intercostal nerves blocked. Therefore, he had preferred at this stage of the operation light general anæsthesia, preferably using gas-oxygen. Again he agreed with Doctor Gibbon that if the Carrel technic of using Dakin's solution is correctly applied bleeding is not likely to occur—Dakin's solution in the proper concentration (.5 per cent.) will not dissolve healthy tissue, having a selective action on necrotic tissue. If the blood-vessel is necrotic there is no reason to believe that it will escape, but this chance is worth taking for the marked benefit to be derived in getting rid of necrotic tissue and infection in general.

Dichloramine-T has not the solvent effect that Dakin's solution has and for that reason is not as valuable as a sterilizing agent. In his opinion it cannot be compared with Dakin's solution in sterilizing quickly large infected cavities. Dichloramine-T is valuable but chiefly so in small surface wounds.

UNILATERAL TUBERCULOSIS OF THE KIDNEY

DR. J. LEON HERMAN (by invitation) read a paper with the above title.

DR. JOHN H. GIBBON said that one troublesome aspect in renal tuberculosis is that there are cases in which it is difficult to be absolutely sure that there is a good kidney on the other side. About fifteen years ago exposure of both kidneys was urged by Leonard Freeman in doing nephrectomy, to determine whether tuberculosis was present in the supposedly good kidney. In one case operated on twelve years ago in which catheterization of the ureters was not possible both kidneys were exposed, and one found to be perfectly normal. The man made a good recovery and has remained well, except that he had tuberculous necrosis

of costal cartilage two years later. In another patient in whom the testicle had been removed for tuberculosis, blood in the urine led to the suspicion of tuberculosis of the kidney. Operation was not submitted to and the man later had an attack of great pain, passing clots down the ureter. The bladder was opened by suprapubic incision by another surgeon, and in that case there was a question which kidney was involved, although the symptoms clearly pointed to the right side. Repeated attempts to catheterize the ureters failed. There was, therefore, nothing left to be done but to expose the kidneys. This was done, exposing the supposedly good kidney first. A small fluctuating area in this kidney was incised and a stream of tuberculous pus escaped. This little abscess had no connection with the urinary tract. The abscess was excised. The other kidney was removed. This has been five years ago, and, while the man may not be called well, he has never developed tuberculosis of the remaining kidney. The interesting feature about this case is that had they been able to catheterize the ureters they would not have learned of the presence of the abscess found in the supposedly good kidney, which was not indicated in any way. Both of these patients were physicians and both are now carrying on an active practice.

Stated Meeting held April 7, 1919

DR. GEORGE G. ROSS, Acting-President, in the Chair

CERVICAL MENINGOCELE

DR. JOHN STEWART RODMAN presented a case of cervical meningocele which had been relieved by plastic operation.

DR. JOHN B. ROBERTS called attention to the fact that the free flap which Doctor Rodman had used was a graft of fatty fascia from underneath the skin, containing also a portion of tendon of the frontalis above the nose. When the protrusion of cicatricial dura and scar tissue was removed, there was exposed a pit three-quarters of an inch deep with a cranial opening about one inch long and half an inch wide, with the long axis horizontal. Some time ago he took a bone plate out of the girl's tibia and planted it in her right thigh under the fascia lata. This he intends to use later to close the defect in the bone of the cranium, if the tendinous fatty graft recently stitched across the opening fails to prevent protrusion of the cerebral membranes. His idea is to use the fascia lata which was fastened by wire to the bone graft as a patch for the dura mater deficiency.

WAR WOUNDS TREATED WITH DICHLORAMINE-T

DR. PENN G. SKILLERN, JR., read a paper with the above title, for which see vol. lxix, p. 498.

DR. J. STEWART RODMAN said that he had had a rather unusual opportunity to watch the use of dichloramine-T at General Hospital No. 14 during

a term of service of some four months this last year. The use of dichloramine-T was under the supervision of Doctor Lee and in charge of Doctor Furness and, therefore, in the hands of experts. He did not feel that dichloramine-T would ever take the place of Dakin's solution, but that there was a definite field for both. The former did not cleanse the large pus cavities as did Dakin's solution because it has not the solvent action of Dakin's solution. The technic of using dichloramine-T is simpler than that necessary in Dakin's solution. Dichloramine-T was really more valuable in the small wounds than in any other place. In the larger wounds, comminuted infected fractures, etc., dichloramine-T certainly did not do the work that Dakin's solution did.

DR. MORRIS BOOTH MILLER said that he had used dichloramine-T throughout the period of our activity in the war. Since September of last year he had seen it used extensively on the wounded soldiers brought back from France. He was entirely convinced that there is no measure which is quite so satisfactory from several standpoints. It is small of bulk, it is easy to apply, it is economical of dressings, it is painless in application, and the quick healing which follows its use, together with these qualities, makes it of great value. Many cases have been brought aboard ship in the last stage of suppuration or of nearly sterile granulation, and they have healed promptly under the use of this measure. There seemed to be no irritation of the healthy skin. Under service conditions they could easily dress 100 cases in one and a half or two hours; the patients made no complaints, especially when it was used in the form of a spray; and the wounds closed with extraordinary rapidity. In the earlier treatment of wounds he thought the Dakin-Carrel solution to be of especial value, but in the terminal stages he knew of nothing to be compared with dichloramine-T.

DR. JOHN B. ROBERTS inquired which is better, the dichloramine-T prepared with the eucalyptol, or with the chlorozone. He had wondered if he did not get as good results in his face cases with tincture of iodine with equal parts of 95 per cent. alcohol, as with dichloramine-T. He tells his patients not to wash the face where the wounds are. In the past he believed much harm had been done by wetting the sutured wounds of aseptic operations. The circumstances are very different in already infected wounds.

DR. JOHN H. GIBBON said that this war has taught surgery that the principal object in the treatment of gunshot wounds is their closure. Between 80 and 90 per cent. of all gunshot wounds, particularly if compound fractures are eliminated, can be closed if operated on within ten hours. Such results depend in turn upon the meticulous care with which this is done. The first operation is the most important step in preventing infection of the wound. If the débridement has been properly performed and for some reason the wound is left open, in a large proportion of cases no antiseptic is required. If infection has occurred some chemical agent

must be used. In his opinion there are two criteria by which the efficacy of any agent may be judged: (1) A demonstrated fall in the bacterial count; (2) ability to close that wound by retarded primary or secondary suture. There are thousands of cases that have been thoroughly tabulated showing what can be done with certain agents, particularly Dakin's solution. In the American Army this was used more extensively than any other. It is to be hoped that Doctor Skillern and Doctor Miller will give some figures in regard to primary and secondary sutures done on the bacterial count or on clinical observation. He knew that practically any wound that has been properly débrided, any wound that has been freed of all foreign material and all dead tissue, can be sterilized with the Carrel-Dakin treatment. Any pleural cavity in which there is no foreign body can be sterilized with Carrel-Dakin solution and closed. If that can be done with dichloramine-T then it ought to be as good as the Carrel-Dakin solution. The care with which the primary operation is done will determine the ease with which the wound is sterilized afterwards if it becomes infected. In one evacuation hospital in the American Army of 500 consecutive wounds, 300 left the hospital with the wounds healed. This, of course, was done in a so-called "quiet period" and not possible in a big battle.

DR. MOSES BEHREND: In an experience of nine months with dichloramine-T as a local antiseptic before operation the results have been better than with the application of iodine. In addition to fewer infections it has been shown experimentally that there are fewer adhesions in the abdomen following its use than after iodine. The use of this agent in abdominal work presents a further argument for the employment of this agent.

DR. GEORGE G. ROSS had had opportunity to use both dichloramine-T and the Dakin-Carrel solution. Unfortunately, he was not able to give an opinion of their comparative value because he used the Dakin-Carrel treatment at a period of great stress when it was impossible to learn anything of final result. He saw a great many cases in which the Dakin-Carrel solution dissolved out the slough as no other agent he had ever used would. At Brest there were many bad burns in which dichloramine-T was used for a while until obliged to discontinue it because of the intense pain. They then resumed the paraffine or ambrine treatment. In the infected wounds, dichloramine-T proved so satisfactory that they gave up the use of the more complicated method of Dakin-Carrel. It must be said, however, that the type of wounds and the character of the infections were very different from those seen as the result of battle wounds. There was no gas gangrene infection to contend with.

DR. GEORGE M. LAWS had an excellent opportunity of comparing dichloramine-T with Carrel-Dakin solution in the treatment of war wounds. During a period of six weeks they were receiving patients at Base Hospital 31 as soon as they could be evacuated after primary opera-

DERMOID CYST IN RIGHT SUBMAXILLARY REGION

tion performed according to the usual custom, and they had a great many large infected wounds to sterilize preparatory to secondary closure. After using both these agents he was impressed with the superiority of the Carrel-Dakin solution in that type of wound. He agreed, however, with those who advocate the use of dichloramine-T in small wounds and various other types.

DOCTOR SKILLERN, closing, replying to Doctor Roberts, said the agent prepared with chlorocazone is what they had on shipboard. It was used by pouring the fluid in and not by spraying; no drain was put in. Referring to Doctor Gibbon's large experience in the Army as compared with the Navy experience, he said that with three or four hundred wounds in various parts of the body and thirty men and three or four surgeons on board, they could not take time to perform débridement, but had to content themselves with simply putting in the dichloramine-T and putting on sterile gauze. Even at the hospital the bacteriological cultures proved sterile. One case was that of compound fracture of the knee-joint and in it there was immediate healing. The fact of not having performed débridement is, I think, a further testimony to the value of this agent.

DERMOID CYST IN RIGHT SUBMAXILLARY REGION

DR. T. TURNER THOMAS presented a girl, seventeen years of age, who about three months before coming under observation had experienced some pain in the right submaxillary region, especially on movement, and at this time it was observed that she had a swelling in that locality. Her mother states that at about eleven years of age after an attack of mumps it was noticed that there was a fulness under the chin suggesting double chin, and that this has been present ever since. He saw her first January 21, 1919. He found a non-inflammatory swelling extending downward slightly below the hyoid bone, forward almost to the median line, backward to the sternomastoid muscle and above to the lower border of the jaw. The most prominent portion protruded to about the level of the external surface of the lower jaw. It was not tender but caused a little pain on movement of the head. The skin was freely movable over it and normal in color and feel. On palpation there seemed to be a slight sense of fluctuation.

At University Hospital, January 23, 1919, under nitrous oxide anæsthesia, an aspirating needle withdrew a fluid which looked as though it might have purulent material in it, and an incision about three-quarters of an inch was made about an inch deep and just above the hyoid bone. A finger was then introduced and after it a closed hæmostat, but no pus escaped. The incision was then enlarged outward and upward to about three or four inches and about parallel to the lower border of the jaw. On exposure of the depth of the wound it was first thought we were dealing with a lipoma, but this proved to be the submaxillary gland stretched out over a mass underneath. The gland was separated and retracted

upward, exposing a mass which had a smooth, even surface and seemed cystic. An incision was made into it with the escape of a large quantity of yellowish bodies, suggesting something having the appearance of the so-called melon-seed bodies with the consistency of sebaceous or cheesy tuberculous material. It had very little fluid in it. Each little separate body was soft and easily crushed between the thumb and finger. The bodies varied in size from that of a pin head to an ordinary large bean. The total quantity could not be determined but it was probably between a half pint and a pint. The finger introduced into the cavity found it very deep and smoothly lined with no indication of inflammatory thickening. The surrounding tissues had a normal feel, *i.e.*, they were of normal softness and mobility. The tissue between the depth of the cavity and the pharynx must have been very thin, because it was at first thought the end of the finger was in the oropharynx and against the back of the tongue which could be distinctly felt. At this period of the operation the patient was vomiting and it was thought some of the cavity contents were coming from the mouth, but this was easily found to be not so. Neither did any vomitus appear in the wound.

As the diagnosis had not been made before operation the question of treatment now became very disturbing. It was evident that we were dealing with a cyst and that the contents represented the secretion of the cyst wall. The best treatment of these cysts is to remove the cyst wall, but this would have been a very formidable operation in view of the extent, depth and attachments of the cyst wall to the pharyngeal wall and in the region of the great blood-vessels and nerves inside of and under the jaw. Marsupialization in cysts of the pancreas has been very successful and he concluded to apply this method of operation in this case. The wound was closed to the lower angle by a subcutaneous cat-gut suture and the edges of the opening in the cyst were sutured to those of the skin at this lower angle. A rubber drainage tube was introduced about two and a half inches and fixed there by a skin suture, and a dressing and bandage were applied. Three days after operation the tube was removed about three-quarters of an inch and entirely in two weeks. The discharge gradually decreased, remained very slight for several weeks and disappeared entirely three weeks ago.

A small section of the cyst wall in the circumference of the opening in it was removed for histological examination together with several of the small caseous bodies found in the cyst. They were studied in the pathological laboratory of the University of Pennsylvania by Dr. F. D. Weidman, who reports as follows:

A section of the specimen of the cyst wall "shows a distinctly squamous lining underlaid by a dense fibrous tissue. The epithelium is of the type seen in skin rather than in the mucous membrane, the basal cells showing nuclei which extend perpendicularly to the basement membrane, the surface ones showing very sharply an arrangement into granular

and keratinous layers. The formation of papillæ is not given. The fibrous tissue below is arranged in collagenous bundles similarly to that seen in the skin, and very frequently bundles of involuntary muscle are met. The individual cells are swollen and degenerate. The feature that clinches the idea that this is skin consists in the presence of several rather large areas of highly vacuolated cells that are distinguishable with difficulty from fatty degeneration in the surface epithelium. Their occurrence, however, below the general level of the surface epithelium and the uniform grade of vacuolization in all of the individual nuclei determines that they are sebaceous. A further diagnostic feature consists in the discovery of two or three delicate (lanugo) hairs which lie within the dilated epithelial lined spaces, immediately adjacent to one of these sebaceous groups, and one of the hairs has a faint yellow tint which is so characteristic of this structure.

"Some of the contents grossly submitted was stained by Soudan III, and even the granular parts assumed a deep orange color which indicates a fatty degeneration. Some was also stained with Van Giesen's stain in an extemporaneous wet specimen, the degenerated cells taking on a green color which changed to yellow when washed in water. This indicates their keratinous nature.

"It appears now very clear that this is a dermoid cyst. The presence of hairs clinches the diagnosis, assisted by the presence of the involuntary muscle which doubtless represents an arrectores pilæ. The sebaceous glands are only less valuable because such are known to occur normally in the mucous membrane of the mouth, and because exaggerations of such very frequently occur in the lips in the condition known as Fordyce's disease. Furthermore, the presence of the granular layer in the surface epithelium is useful because the writer believes that this never occurs in a mucous membrane. The failure of the keratinous papillæ is of no moment because this is usually the case in dermoid cysts. Of the two possible sources of this cyst the writer (Doctor Weidman), therefore, feels certain that it sprang from the skin rather than the mucous membrane and that the lesion belongs to the inclusion dermoids."

DR. PENN G. SKILLERN, JR., said that he could add something of definite interest to Doctor Thomas' case of dermoid cyst in that nine days ago he had almost exactly the same experience in a patient operated upon a year ago for a swelling of the neck. The left submaxillary, salivary and sublingual glands were removed. Five months afterward the swelling came back. There was sudden pain with the swelling. The jaw was not tender but there was present a sense of fluctuation upon pressure. The swelling was pointed up like a frog's belly. The history given by Doctor Thomas of sudden pain beneath the jaw followed by swelling suggested submaxillary salivary calculus.

DR. DAMON B. PFEIFFER said that he had seen pathologically and clinically several cases which correspond closely to the case reported by

Doctor Thomas. It seemed to him that the case can with perfect propriety be regarded as one of bronchial cyst. Such a cyst arises from the inclusion of a portion of an embryonic bronchial cleft and the type of lining epithelium found in one of these cysts is determined by the portion of the cleft which chanced to be cut off. Thus, if the included portion of the cleft possesses an ectodermal lining, the resulting cyst will be similarly lined, as in the case under discussion. It is not improper to call this cyst a dermoid or, if you prefer, an epidermoidal cyst, but this does not exclude its bronchiogenic origin.

He recalled a case similar to the one under discussion in which the surgeon merely incised and drained under the impression that he was dealing with a cold abscess. It was necessary subsequently to remove the sac to cure the resulting sinus. It should be remembered that the contents of these cysts vary in character from a clear serous material to a thick grumous or cheesy substance like that found in sebaceous cysts. Of it may resemble very closely the contents of tuberculous abscesses. It is important to make the correct diagnosis at the time of operation since the cyst calls for complete excision and the wound may be closed without drainage. Naturally this rule may require modification in the presence of circumstances such as have just been reported or in the rare event that true infection has been implanted in the cyst.

DR. HENRY R. WHARTON said that some years ago he reported before this society three cases of sublingual cyst. The tumors were large and extended down from the hyoid bone. Two occurred in children and one in a woman forty years of age. The microscopic examination showed them to be dermoids. He was surprised at the ease with which they were enucleated, one through an incision in the floor of the mouth beneath the tongue; the other two through an internal incision below the chin extending down to the hyoid bone.

RETROPERITONEAL APPENDIX

DOCTOR THOMAS presented a young colored woman, who was operated on at the Philadelphia General Hospital, July 16, 1918, for appendicitis of mild character. McBurney incision. No adhesions. When the cæcum was pulled out of the abdominal wound and retracted inward, the appendix was seen embedded in the retroperitoneal tissue to the outer side of the cæcum and curled on itself. The peritoneum could be picked up by forceps and easily and freely pulled away from the appendix which continued to lie in its original position. It, therefore, had no mesentery and the overlying peritoneum could be made to slip backward and forward over it by a little pressure of the finger. The peritoneum was cut over the appendix between two forceps, its margins were retracted and the appendix brought into the peritoneal cavity through this opening. Some difficulty was experienced in isolating and grasping the appendicular vessels with hæmostatic forceps and also in ligating and dividing them. The

INTUSSUSCEPTION OF HEAD OF CÆCUM

peritoneal opening was then closed by catgut sutures over the stump of the appendix which was then again in its original retroperitoneal position. Recovery was uninterrupted. Everything seemed to indicate that this was surely a retroperitoneal appendix.

INTUSSUSCEPTION OF HEAD OF CÆCUM WITHOUT INVOLVEMENT OF ILEOCÆCAL VALVE

DOCTOR THOMAS presented, also, a boy, thirteen years old, strong and healthy until present trouble began. Referred by Dr. Geo. E. Shaffer. Admitted to Northeastern Hospital July 10, 1918. On the day before admission he was seized with an abdominal pain and vomiting. The bowels had not moved for two days when on the morning of admission he had a movement which contained macroscopic blood. There was then marked rigidity of the entire abdominal wall with tenderness in the appendiceal region and a diffuse pain around it. Doctor Shaffer had found on palpation a lump between the last rib and McBurney's point. The interne failed to find it, but when the patient was under ether it was again detected. A diagnosis of appendicitis had been made because of the fever and increased pulse, the severe tenderness and abdominal rigidity, the preceding two days constipation, and a possible mass in the appendiceal region. Operation was done soon after admission. McBurney incision. The appendix was located after some difficulty and only in part, the basal portion being concealed in an ill defined mass which exhibited much induration but no adhesions to surrounding tissues. It had little mobility and could not be brought into the wound and the appendix could not be released from its imprisoned position. The ileocæcal junction was not involved in the mass. A higher incision was made along the outer margin of the rectus muscle, extending upward to about two inches of the costal margin. It was still difficult to outline and determine the character of the mass, and, while it was being manipulated, suddenly the appendix was released and the cæcum took its normal form. It now seemed evident that we were dealing with an invagination of the end of the cæcum which had carried in with it that portion to which the appendix was attached. The cæcal wall was much thickened by œdema which also involved the appendix to such a degree that it protruded rigidly through the lower incision. The whole involved portion of intestine including the appendix had a bluish discoloration indicating the probable threatening of a gangrenous process. This rapidly disappeared after the correction of the invagination. The appendix was removed, both wounds closed and healing was uninterrupted.

In the sixth volume of Keen's "System of Surgery," John B. Murphy calls attention to Moschowitz's detailed report of intussusception of the appendix, and refers to six more recent cases. He felt satisfied that in this case the intussusception of the appendix was only a part of that of the cæcum. If this condition had continued to progress it could only

have done so by the development of an ordinary ileocaecal intussusception. This case, therefore, may have been only the earliest stage of this common variety of intussusception.

STRANGULATED OBTURATOR HERNIA

DR. EDWARD J. KLOPP reported the case of a female, age eighty-eight, referred by Doctor Broadbelt, admitted to the Jefferson Hospital January 28, 1919. Four days before admission she was seized suddenly with general abdominal pain. The bowels did not move but had moved on the previous day. The following day she vomited from fifteen to twenty times, the vomitus was dark in color and had a very foul odor. Vomiting continued up to the time of operation. Laxatives and enemas were used freely without effect. On examination the patient presented nothing noteworthy except a mitral systolic murmur and marked arteriosclerosis. The abdomen was moderately distended, no engorgement of the superficial veins, tympanitic and soft throughout, tenderness over both lower quadrants and no abnormal masses palpated. No evidence of hernia in the inguinal, femoral, or umbilical regions. Vaginal and rectal examinations revealed nothing of importance. Temperature, normal; pulse, 100; respiration, 24. Diagnosis: Intestinal obstruction, cause unknown.

The patient was operated upon immediately under nitrous oxide and oxygen anæsthesia. The abdomen was opened through a median incision below the umbilicus. A portion of distended small bowel came into view; it was engorged, œdematous, and dark red in color. After following this bowel in the direction of most congestion the obstruction was found in the right obturator foramen. By gentle traction the strangulated loop was drawn out, which comprised an inch and a half of bowel. The hernial sac was removed and the ring closed with chromicized catgut sutures. The abdomen was closed without drainage.

There were two spontaneous bowel movements within twelve hours after the operation, and one or more movements every day thereafter. She vomited on the seventh day following the administration of a Seidlitz powder. She was out of bed on the tenth day. Everything seemed to go well until the night of the eleventh day when there was sudden collapse, and death in two hours. No autopsy was done, but we had no reason to think that obstruction had recurred.

SARCOMA OF SCIATIC NERVE

DR. EDWARD J. KLOPP reported the case of a male, age eighteen, who was admitted to Doctor Stewart's service, Jefferson Hospital, May 31, 1917. He complained of a painful swelling on the posterior aspect of the thigh. No acute illness since childhood except typhoid fever at ten; no venereal disease and no history of injury. Two months before admission he began to have pain in the left thigh posteriorly radiating down the leg, especially noticed on walking and at times on sitting down. Later the pain became so severe that it was almost impossible for him to walk. About

two weeks after the onset of pain he noticed a swelling on the posterior surface of the thigh. Appetite and digestion fair, bowels constipated. The patient is rather a poorly developed and poorly nourished adult male. General examination is negative. On the left thigh posteriorly, six inches below the gluteal fold, is a hard, irregular, tender mass about three by four inches. It is distinctly outlined, can be moved laterally but not vertically.

On June 1, 1917, under general anæsthesia, an incision was made over the mass in the long axis of the thigh. The long head of the biceps was adherent to or perhaps involved by the growth, hence a portion of the muscle was cross cut above and below, about an inch beyond the growth. After exposing the sciatic nerve it seemed to tunnel the growth. Separation was impossible, therefore the sheath, with probably one-half of the nerve cord, was excised for a distance of two inches. The adductor magnus and the semitendinosus were apparently free. A small wick of gauze was inserted for drainage. He left the hospital eight days after the operation with the wound healed.

Dr. E. D. Funk made the following laboratory report:

"Specimen weighs 180 gms. and measures 13 by 5 by 5 cm. The principal portion is composed of dark red muscle, œdematous and somewhat flabby. Attached to it and surrounded by a grayish, œdematous membrane is an oval mass measuring 5.5 by 4 cm. This tissue is quite resistant, yellowish-gray and incised with resistance. The outer portions of the incised surfaces are porous, somewhat brittle and resemble cartilage. The rest of the tissue is grayish in color, tough and resistant.

"Fixation in Zenker's solution; staining by usual laboratory methods."

Diagnosis.—Osteosarcoma.

Histology.—The section shows only tumor structure which consists of immature bone. The lamellæ stain lightly and contain many osteoblastic cells. The cells within the lacunæ and canaliculi are large and oval or spindle-shaped. Between the strands of immature bone are many irregularly shaped cells, loosely arranged and very vascular.

A month after operation he had pain again. Shortly after this a mass appeared in the region of the scar. He was readmitted to the hospital and on August 6, 1917, the growth was removed. The sciatic nerve seemed to be involved as before, the growth was approximately the same size as that of the former operation. The growth, with attached muscle, and the nerve for a distance of four inches, were excised. The wound was closed with silkworm-gut drainage.

On August 11, he received one-fourth minim of Coley's fluid. He had twenty-eight injections representing a total of seventy minims, the maximum dose being four and one-half minims. The injections were given at intervals varying from one to four days.

He received six X-ray treatments under the direction of Doctor Manges.

PHILADELPHIA ACADEMY OF SURGERY

Dr. E. D. Funk made the following laboratory report: "Specimen is a tumor removed from the left thigh measuring 9.5 by 7 by 4 cm. and weighing 148 gms. Tissue is dark red in color and very firm, having muscle attached. The main tumor mass measures 3.5 cm. in diameter and is the consistency of bone. A small mass attached to one end is of cartilaginous consistency and yellow in color."

Fixation.—Zenker's solution. Usual laboratory staining.

Histology.—Fibrosis is marked, the nerve sheath is thickened. Many of the fibrous cells are embryonic in character. In the intervening tissue are many thick-walled blood-vessels.

Diagnosis.—Fibro-neuroma.

We believe this to have been a case of sarcoma of the sheath of the sciatic nerve, because of the clinical appearance and laboratory findings and because of the prompt recurrence before the nerve was excised.

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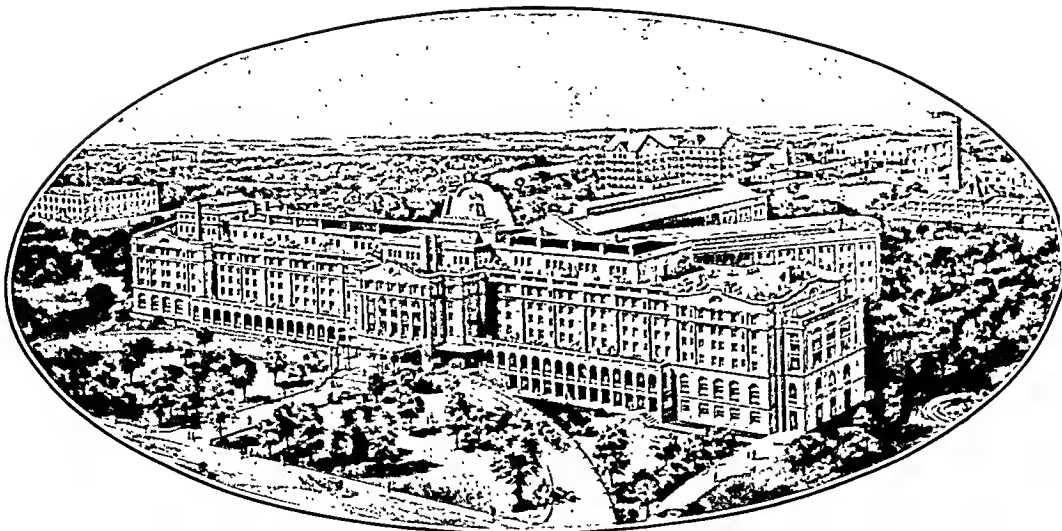
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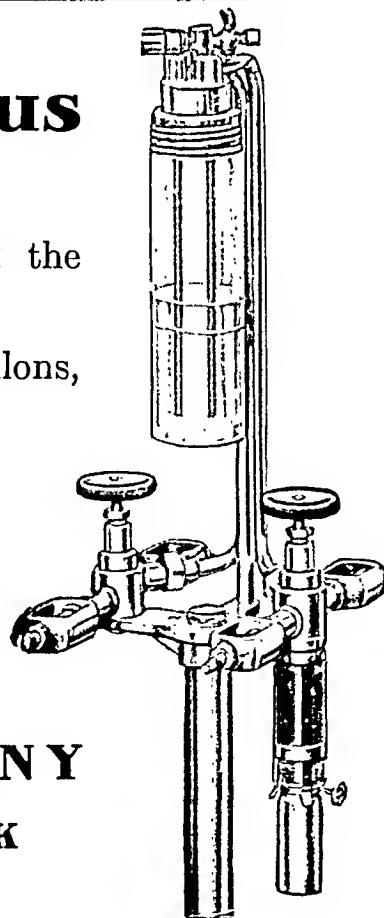
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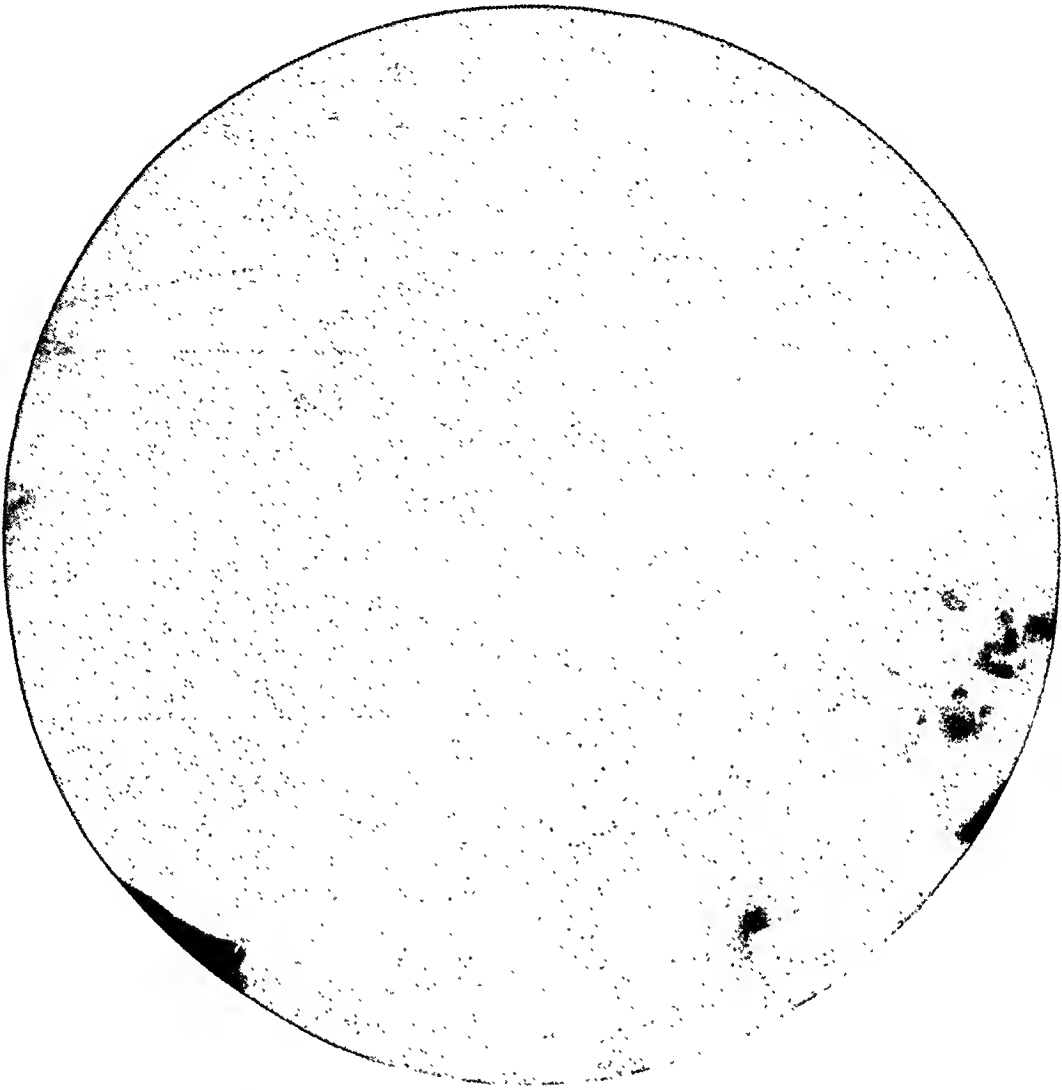
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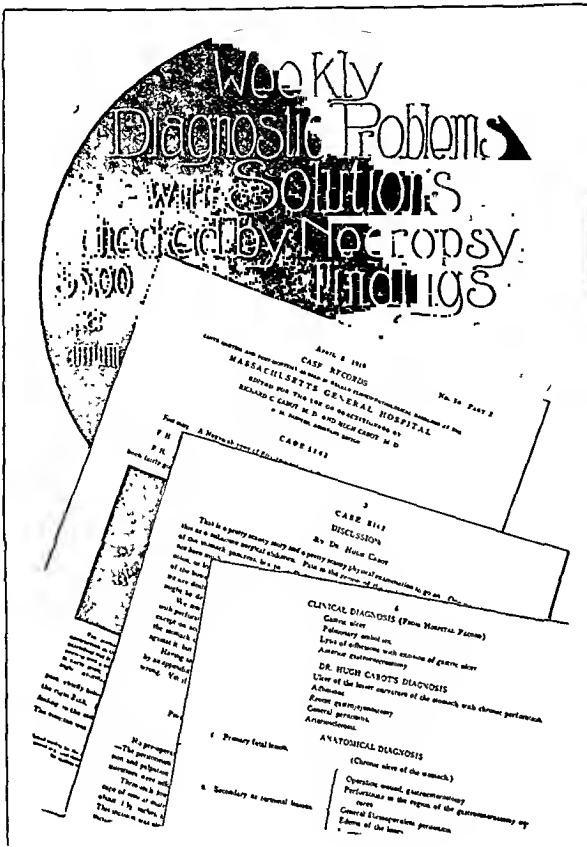
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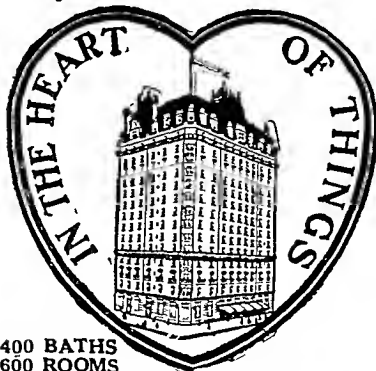
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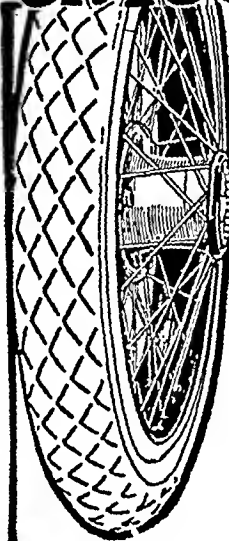
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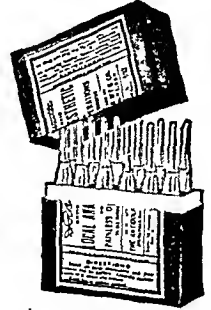
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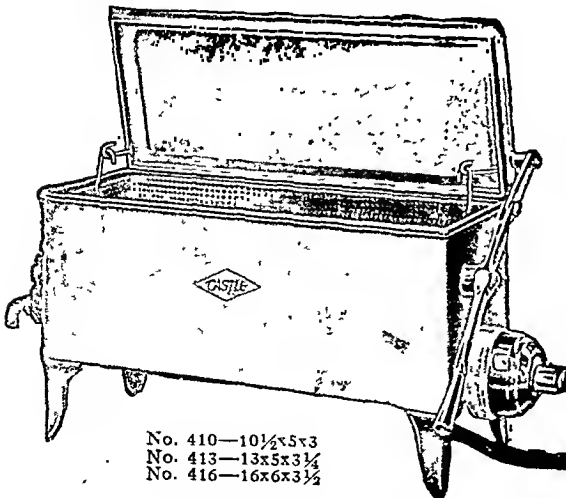
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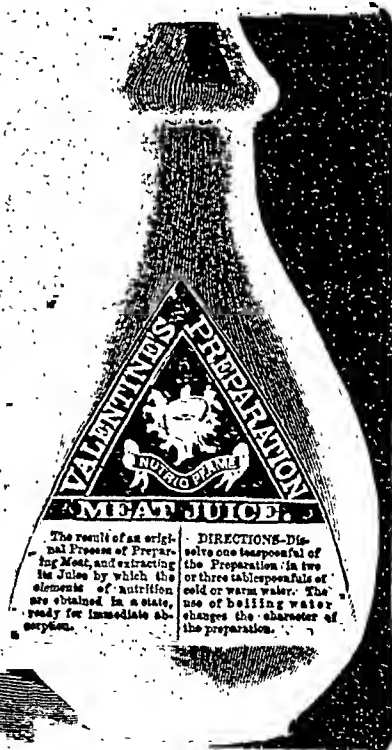
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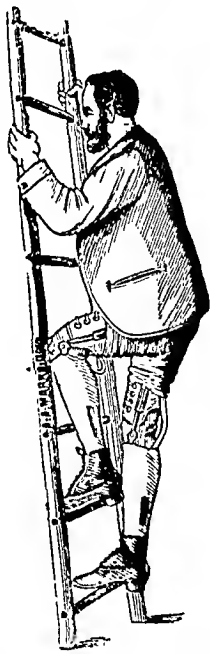
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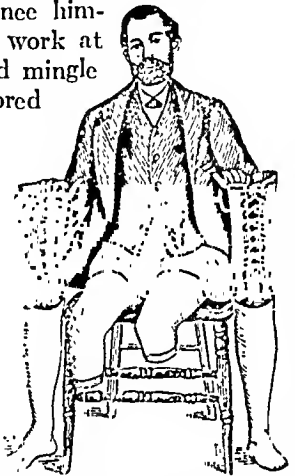
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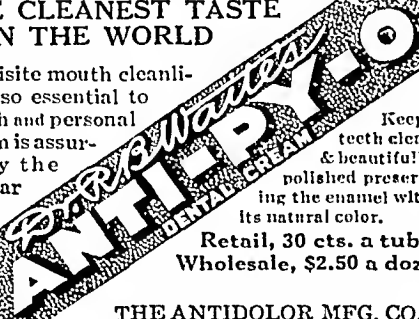
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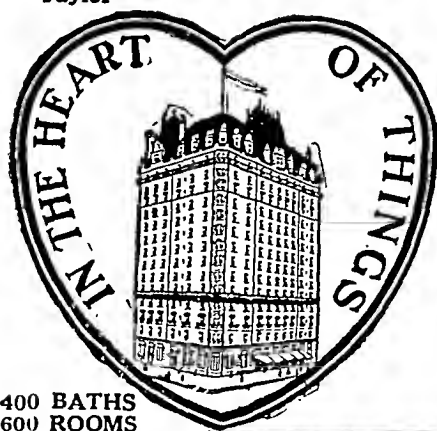
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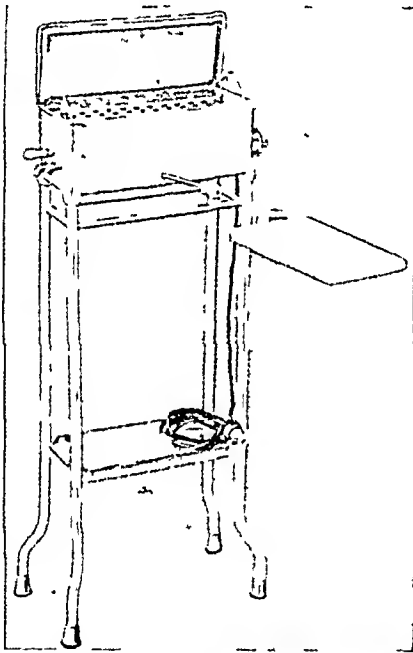
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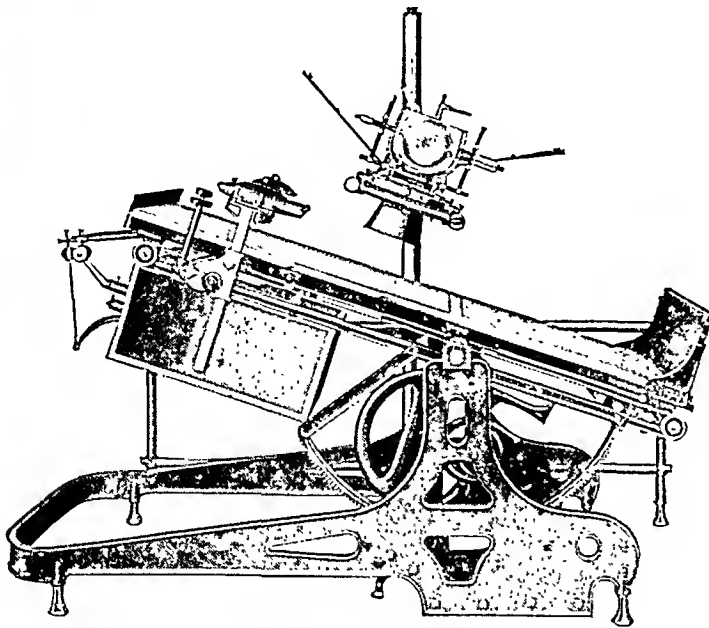


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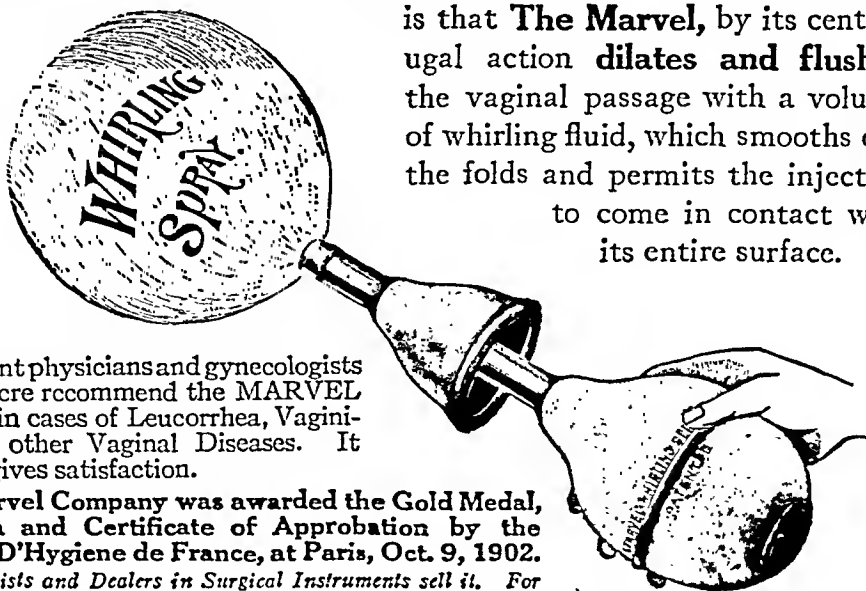
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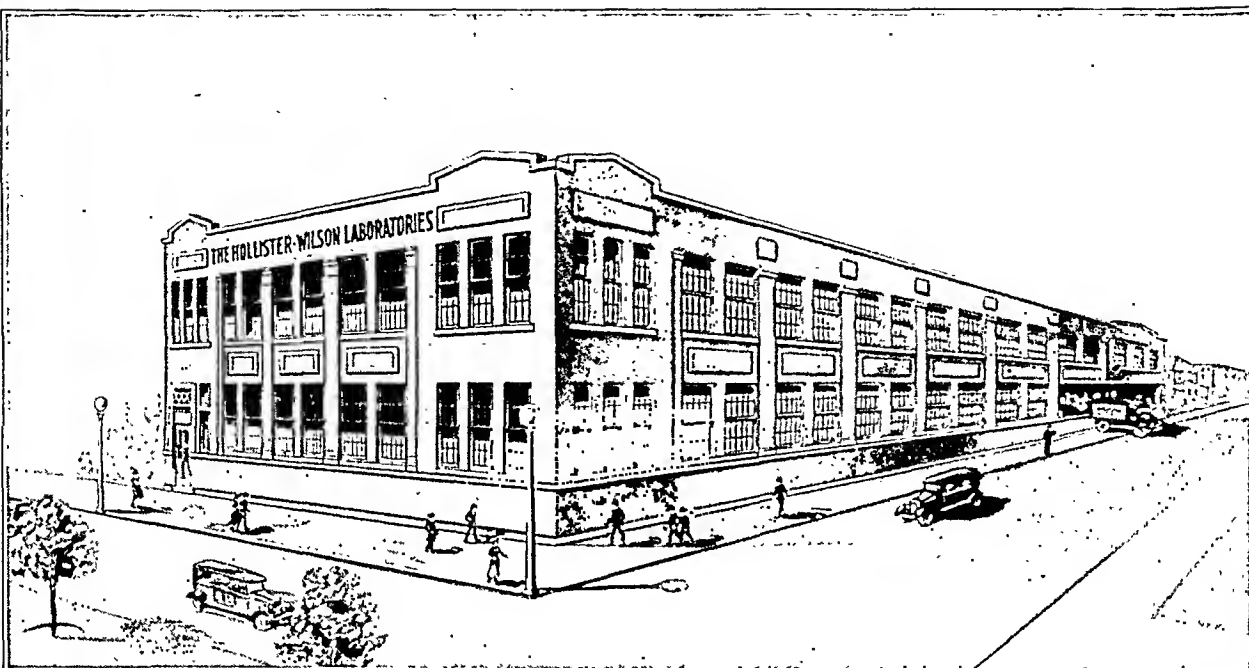
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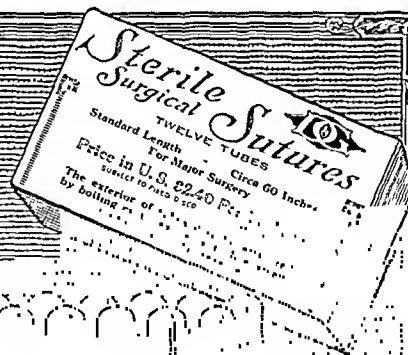
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ANNALS *of* SURGERY

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No. 2

EXPERIMENTAL HYDROCEPHALUS*

BY WALTER E. DANDY, M.D.

OF BALTIMORE, MD.

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THE production of all types of hydrocephalus by precise experimental methods finally lifts the idiopathic veil and reveals hydrocephalus as a disease with a clearly defined etiology and pathology. The first evidence that hydrocephalus could be experimentally produced was incorporated in an article with Blackfan in 1913.¹ It was demonstrated that when a tiny obstructing body was introduced into the aqueduct of Sylvius of a dog, all the cerebral ventricles proximal to the occlusion became dilated; distally, the size of the fourth ventricle was not changed.

The following year, Thomas² published additional experimental evidence that hydrocephalus was caused by obstruction. Following the injection of aleuronat granules into the lateral ventricles, the iter became plugged; organization of the granules resulted in total occlusion of the opening and hydrocephalus followed.

As early as the middle of the eighteenth century, Haller, Brunner and Litré looked upon an obstruction to the outflow of the ventricular contents through the pituitary body as the cause of hydrocephalus. Such a theory of obstruction can only be regarded as fanciful, since vapor and not fluid was at that time regarded as the normal content of the ventricles; the pituitary body was erroneously regarded as the main avenue of escape for the vapor in the ventricles.

Magendie (1825) first described an anatomical obstruction at the base of the brain in several cases of hydrocephalus, but he was not entirely convinced that the obstruction was the cause, because he regarded the pia as the source of all cerebrospinal fluid. Reasoning from this viewpoint, he

* Read by title before the American Surgical Association, June 18, 1919.

† These studies have been conducted in the laboratories of Professor Halsted. His suggestions have been invaluable in the development of many new problems in a virgin experimental field. The success of many of the crucial experiments is in large part due to consultations with him.

¹ Dandy, W. E., and Blackfan, K. D.: Internal Hydrocephalus. An Experimental, Clinical and Pathological Study. *J. Am. M. Assn.*, 1913, lxi, 2216. Also *Am. J. Dis. Child.*, 1914, viii, 406; *Am. J. Dis. Child.*, 1917, xiv, 424; *Beitr. z. klin. Chir.*, 1914, xciii, 392.

² Thomas, W. T.: Experimental Hydrocephalus. *J. Exper. Med.*, 1914, xix, 106.

expected an obstruction to cause dilation of the ventricles posterior rather than anterior to the obstruction. Throughout his publications he was much perplexed by his inability to correlate these pathological findings with his physiological conceptions. He never suspected the choroid plexus as the organ of secretion of the cerebrospinal fluid. The findings, therefore, were inconclusive. Despite his mistaken interpretations, the cases stand as probably the first in which a mechanical obstruction was described and considered to have a bearing on the disease.

Two additional discoveries of the greatest importance were made by Magendie, without which any consideration of the etiology of hydrocephalus would still be useless. He first established the fact that fluid and not air or vapor fills the ventricles and the subarachnoid space in the living; and he discovered the foramen of Magendie, an opening which establishes communication between the ventricular system and the subarachnoid space.

Hilton (1860) did a great deal more to confirm the view that obstruction was the cause of hydrocephalus. He accurately described and made drawings of obstructions in three cases of hydrocephalus; in one a stenosis was in the aqueduct of Sylvius, and in two cases the foramen of Magendie was closed by a scar. In each, hydrocephalus resulted proximal to the obstruction. Numerous examples of obstruction have since been added, but with little additional influence in overcoming a very strong prejudice against the acceptance of the obstructive theory of hydrocephalus.

Opposed to the obstruction theory was the impressive argument that in most cases of hydrocephalus there was no obstruction, and even no cause of any kind could be found. Those who held this negative opinion looked upon obstruction in the remaining cases as purely incidental and in no way etiological; all cases of hydrocephalus were considered idiopathic.

A third school conceived two entirely different types of hydrocephalus: (1) in which an obstruction produced the disease, and (2) in which no cause could be found. The second type they regarded as idiopathic.

The existence of the foramen of Magendie is even now disputed by eminent authorities. Magendie himself admitted, as is now well recognized, that his foramen is not present in dogs and other animals. Why then should it be significant for man? Many still consider this foramen an artefact, as other foramina which have been described have proved to be.

In 1855 Luschka made a discovery which clarifies much of the earlier confusion and makes a theory of obstruction tenable. He discovered two additional openings between the fourth ventricle and the subarachnoid space, making with the foramen of Magendie three in all. These openings, now known as the foramina of Luschka, are also present in all animals; their presence makes it clear why the foramen of Magendie may be absent without hydrocephalus.

But the knowledge of the anatomy of the cerebrospinal spaces and the circulation of the cerebrospinal fluid in these spaces has been very vague. If the fundamental facts are so uncertain, any discussion of the etiology

EXPERIMENTAL HYDROCEPHALUS

of the disease must be fruitless. The experiments here presented will clear any uncertainty about the grosser anatomy of the cerebrospinal spaces as well as the normal circulation of the cerebrospinal fluid and the results following the interference with the normal pathways for this circulation.

A very simple experiment will demonstrate the existence of a communication between the ventricles and the subarachnoid space. If phenolsulphonaphthalein or any other inert colored solution is injected into a lateral ventricle it will quickly appear in the spinal fluid removed by lumbar puncture. The location of the communication can be demonstrated by the exclusion of the third and both lateral ventricles, thus limiting the communication to the fourth ventricle. If the aqueduct of Sylvius is occluded experimentally or if, in a patient, it is occluded by any pathological process, the colored solution will not appear in the spinal fluid following an intraventricular injection. This limits the location of the communication to the fourth ventricle. This communication is by the foramina of Luschka and Magendie, can be demonstrated in any brain at necropsy. At any cerebellar operation the foramen of Magendie can easily be seen. So necessary are these openings that when all are absent, as indicated by the phenolsulphonaphthalein test, an internal hydrocephalus invariably must result. The presence of a communication can also be demonstrated by the introduction of air into the lateral ventricle. The air will pass externally and appear in the cisternæ and the sulci over the cerebral hemispheres. The air can be photographed in the X-ray,³ and it can even be seen passing through the foramen of Magendie into the cisterna magna if one makes a fluoroscopic examination.⁴ By these simple tests the possibility of producing an artefact is out of question. The remaining anatomical and physiological facts will be deduced from the succeeding experiments.

HYDROCEPHALUS PRODUCED BY PLACING AN OBSTRUCTION IN THE AQUEDUCT OF SYLVIVS

These experiments were conducted on dogs, under ether anæsthesia. The midportion of the squamous occipital bone, including the posterior margin of the foramen magnum, was removed with rongeurs and the dura opened in a stellate fashion. By gently elevating the cerebellum, the roof of the fourth ventricle was exposed, perforated, and a tiny piece of cotton cautiously pushed forward on the point of a fine graduated carrier. It was passed over the medulla and pons until it glided into the aqueduct of Sylvius, where it was deposited by withdrawal of the carrier. An improved technic of this procedure consists in inclosing the cotton in an oiled gelatin capsule, which soon dissolves in the cerebrospinal fluid (Fig. 1). The aqueduct of Sylvius is fairly easily recognized by the sense of touch imparted to the

³ Dandy, W. E.: Ventriculography Following the Injection of Air into the Cerebral Ventricles. *ANNALS OF SURGERY*, July, 1918.

⁴ Dandy, W. E.: Fluoroscopy of the Cerebral Ventricles. *Bull. Johns Hopkins Hosp.*, February, 1919.

finger which is directing the entry of the obstruction. The constriction at the terminus of the funnel-like approach from the wide fourth ventricle denotes the entrance to the narrow aqueduct of Sylvius. The iter is, moreover, at a constant measured distance from the posterior border of the cerebellum. If the head is not held in a strictly median position, it is easily possible to make a false passage into the contiguous soft brain tissue, with permanent injury to the pyramidal tract and the nuclei of the cranial nerves.

By producing hydrocephalus with a tiny obstruction in the aqueduct of Sylvius, the etiological rôle of an occlusion is absolutely established. Being a single precise process and involving no neighboring structures, other possible explanations of the resultant hydrocephalus are precluded. When an obstruction is present in any part of the ventricular system, the ventricles always dilate anterior to the occlusion. Following occlusion of the aqueduct of Sylvius, therefore, the third ventricle and both lateral ventricles become distended. The size of the fourth ventricle remains unchanged.

Fig. 2 shows sections of dog's brain one month after the obstruction was introduced. Doubtless, for some time after the cotton was placed in the iter, there was only a partial occlusion, which became complete with organization of the foreign body. The animals become lethargic and there is intermittent vomiting. Ventricular dilatation is accompanied by a corresponding degree of cerebral destruction. The experiments were all performed on dogs after union of the sutures of the skull, so that enlargement of the head could not occur. In animals operated on at birth or soon thereafter, the characteristic hydrocephalic enlargement of the head will necessarily be an outstanding feature which cannot be duplicated when the animal is older.

From this series of experiments we have absolute evidence, (1) that *cerebrospinal fluid forms in the cerebral ventricles*; (2) that *absorption of fluid in the ventricles is at least less than the production*; (3) that *the aqueduct of Sylvius is a necessary outlet from the third and both lateral ventricles*; and (4) that *there are no collateral channels which assume the function of the iter when it is occluded*.⁵

UNILATERAL HYDROCEPHALUS PRODUCED BY OCCLUDING ONE FORAMEN OF MONRO

Since the third and both lateral ventricles distend following occlusion of the aqueduct of Sylvius, it is reasonable to expect that an obstruction at one foramen of Monro will produce dilatation of the corresponding lateral ventricle; that is, a unilateral hydrocephalus.

Spiller⁶ has published a case of unilateral hydrocephalus with occlusion of one foramen of Monro. The occlusion of the foramen was due to a cica-

⁵ For the data concerning the place and manner of formation and absorption of cerebrospinal fluid, the reader is referred to the article previously cited in the *American Journal of the Diseases of Children*.

⁶ Spiller, W. G.: Two Cases of Partial Internal Hydrocephalus from Closure of the Interventricular Passages. *Am. J. M. Sc.*, 1902, p. 44. Also *J. Am. M. Assn.*, 1907, xlviii.

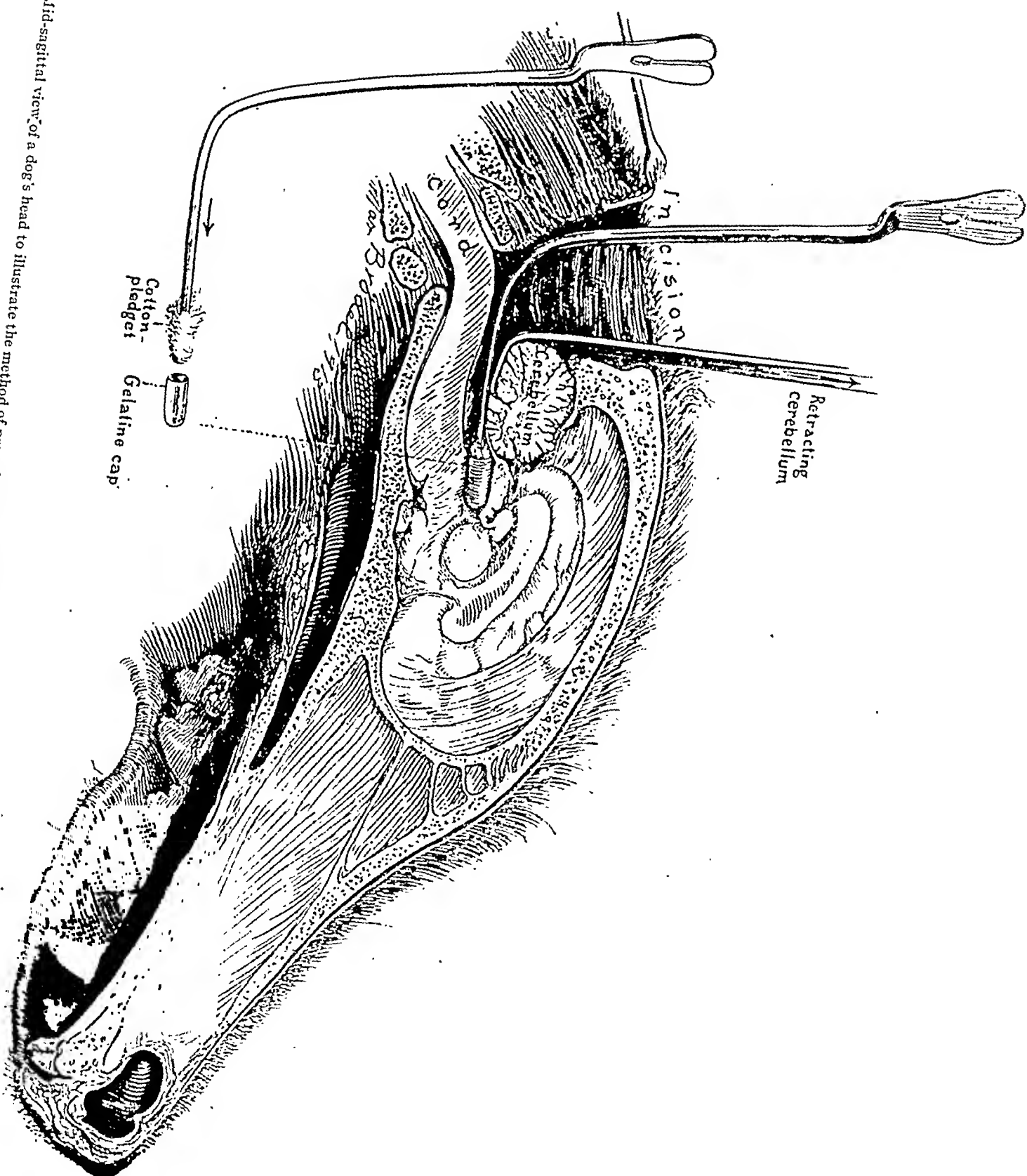


FIG. 1.—Mid-sagittal view of a dog's head to illustrate the method of procedure in occluding the aqueduct of Sylvius. By this method hydrocephalus results, involving the third and both lateral ventricles.



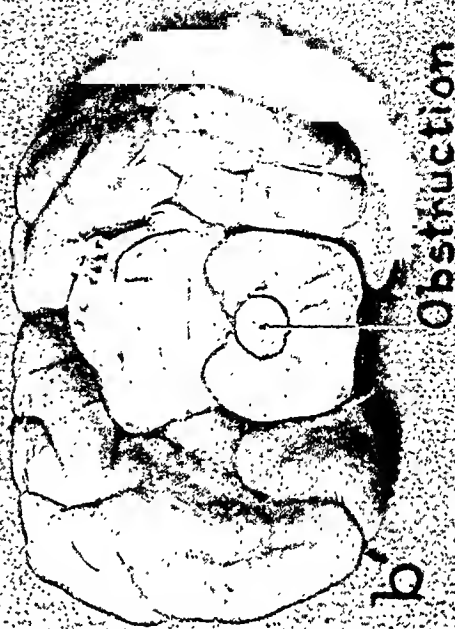
a



b



a'



b'

Obstruction

FIG. 2.—Hydrocephalus of one month's duration resulting from an occlusion placed in the aqueduct of Sylvius (*b* and *b'*), as demonstrated in Fig. 1. *a* and *a'* are sections of a normal dog's brain at levels corresponding to *b* and *b'*. Note the fusion of both lateral ventricles (in *b*) following atrophy of the septum lucidum. The obstruction is shown in the iter (*b'*).

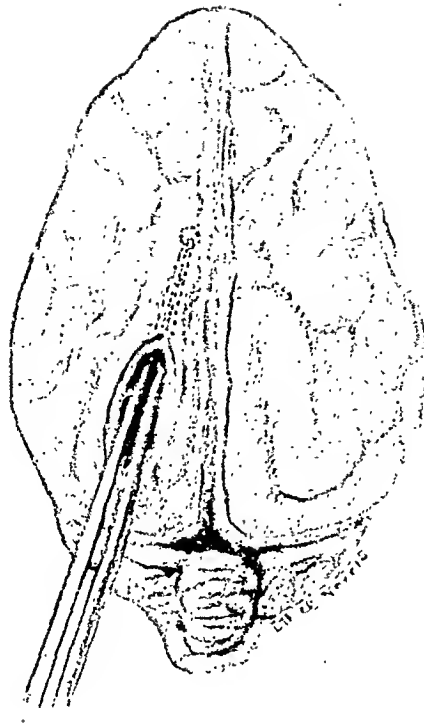


FIG. 3.—To demonstrate the method of introducing a piece of fascia into the foramen of Monro of a dog's brain. A transcortical incision into the ventricle at this point also permits complete choroid plexectomy of one lateral ventricle. Being well posterior, injury to the pyramidal tract is also avoided.

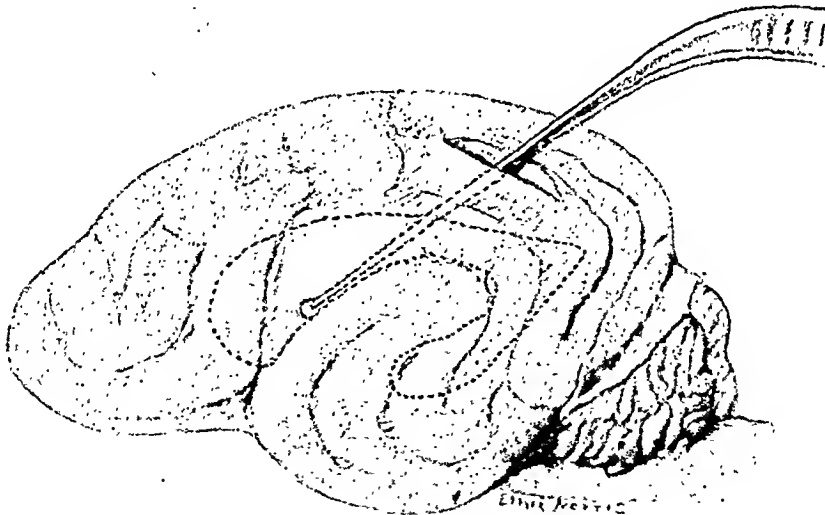


FIG. 4.—Lateral view of a dog's brain to show method of occluding the foramen of Monro. The outline of the lateral ventricle is shown by a dotted line.



FIG. 5.—Photograph of sections of a dog's brain in which a unilateral hydrocephalus has followed occlusion of the left foramen of Monro. The right ventricle is normal



FIG. 6.—Views of another brain with unilateral hydrocephalus. Note the thinning of the cortex as contrasted to the normal (right). The scar in the cortex (upper photograph) is due to closure of the transcortical incision. A ventricular fistula never follows opening the ventricle.



FIG. 7.—Section of a dog's brain three months after the left foramen of Monro was blocked, *but in which the entire choroid plexus of this ventricle was removed.* The left ventricle is a mere slit, the right ventricle is normal. The transcortical defect is shown in the left side. Contrast the left ventricle in Figs. 5, 6, and 7. In all, the foramen of Monro has been occluded but removal of the choroid plexus (Fig. 7) prevents hydrocephalus from forming. This is absolute evidence that the choroid plexus secretes cerebrospinal fluid and that ependyma takes no part in its formation.

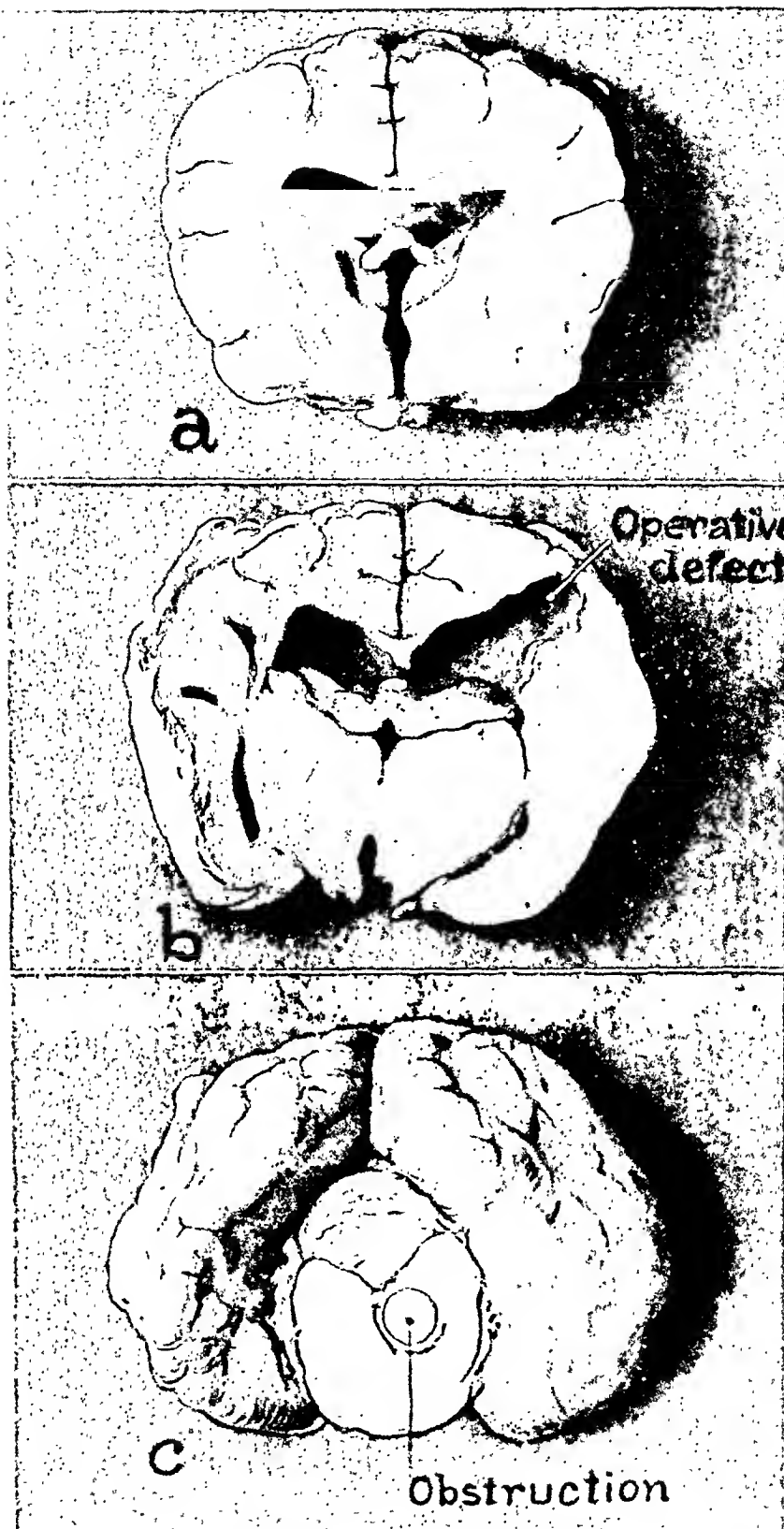


FIG. 8.—Sections of a dog's brain showing hydrocephalus of five weeks' duration resulting after occlusion of the aqueduct of Sylvius, but in which the choroid plexus of both lateral ventricles was removed at the same operation. The accumulated cerebrospinal fluid forms solely from the choroid plexus of the third ventricle. Since both foramina of Monro are patent the distention of the lateral ventricles is a necessary sequel to the obstruction in the aqueduct of Sylvius. The remains of the septum lucidum are still evident in *b*. The obstruction (*c*) is slightly beyond the midline but effectively closes the iter.

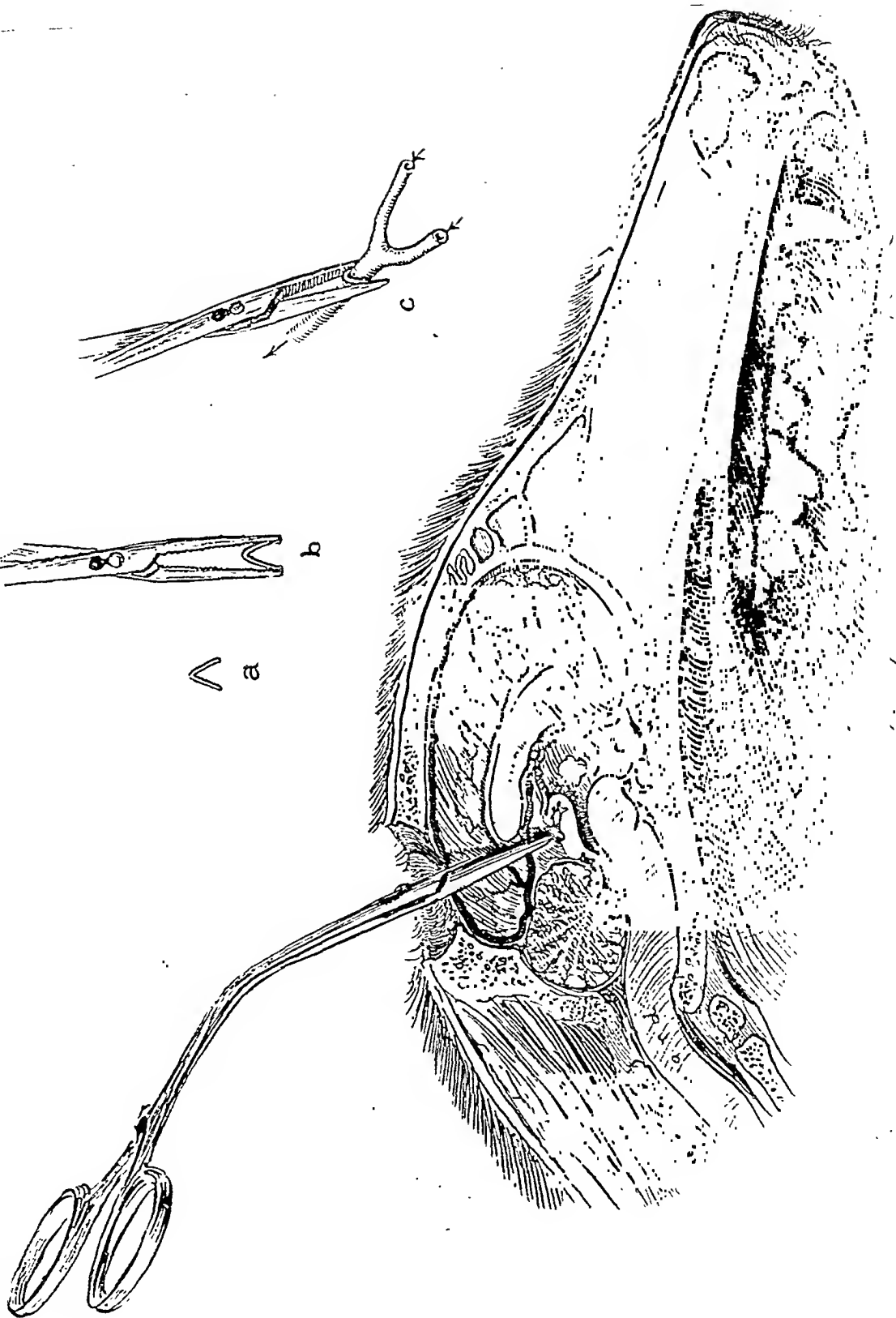


FIG. 9.—Illustration of the method of procedure in ligating the great vein of Galen in a dog. A silver clip is placed astraddle of the vein which is very deeply situated. Compression of the clip occludes the vessel.

trix, probably, of tuberculous origin. I have had under observation a case in which a pedunculated glioma was suspended in the left lateral ventricle and periodically closed the left foramen of Monro. With each occlusion severe headaches, vomiting, partial hemiplegia ensued. Following each attack there was complete subsidence of the signs and symptoms. Doubtless the free intervals were synchronous with the period in which the foramen of Monro was open. Gradually the attacks became more frequent and more violent, and one week before death a final attack began and terminated in death. The affected ventricle was greatly enlarged; the foramen of Monro was completely filled by the tumor which had been forced into the foramen and there became impacted. Part of this obstructing tumor could be dislocated, leaving the foramen of Monro only partially occluded.

The foramen of Monro of a dog can be blocked by inserting either a small piece of fascia or peritoneum (Figs. 3 and 4). Eventually the transplanted tissue becomes incorporated in a cicatrix and total occlusion of the foramen results. The foramen of Monro is reached for this procedure by a transcortical incision which opens into the body of the lateral ventricle well posteriorly. The opening in the brain is maintained by an open nasal speculum. Through this window the foramen of Monro can be seen well forward, where the choroid plexus makes a sharp turn into the third ventricle. The margins of the foramen are scarified before introducing the piece of peritoneum or fascia. The cortical defect is sutured with fine silk. A unilateral hydrocephalus develops on this side (Figs. 5 and 6). There is, of course, no change in the opposite lateral ventricle. Curiously, the cortical opening heals without formation of a ventricular fistula or hernia, despite the total occlusion of the foramen of Monro and the resulting accumulation of cerebrospinal fluid. The healing is similar to the spontaneous closure of an opening made in the corpus callosum for the attempted relief of internal hydrocephalus. It is almost impossible to maintain an artificial opening in a cerebral ventricle.

OCCLUSION OF THE FORAMEN OF MONRO AFTER REMOVAL OF THE CHOROID PLEXUS

The entire choroid plexus of one lateral ventricle can be removed through the same transcortical incision that is made in order to plug the foramen of Monro. If choroid plexectomy is to be done, the incision in the cortex should be even more posteriorly—into the posterior horn of the ventricle—so that the descending horn and the body of the lateral ventricle can be directly illuminated at the same time. The choroid plexus can then be seen through its entire extent. The choroid plexus is picked up with delicate forceps at the foramen of Monro and stripped from its attachment to the velum interpositum as far as the glomus. The tip of the choroid plexus in the descending horn is then picked up and stripped in a similar manner until the glomus is reached. In this way the entire choroid plexus can be removed in one piece.

Numerous tiny blood-vessels enter the choroid plexus through its narrow edge of attachment to the ventricular wall. The vessels, however, are quite small, and the slight bleeding can be easily controlled by pledgets of cotton moistened in warm saline solution.

If the entire choroid plexus is removed and the foramen of Monro is blocked at the same time, the ventricle becomes obliterated (Fig. 7). A marked contrast is produced by blocking the foramen of Monro on the opposite side without removal of the choroid plexus. Both foramina of Monro being occluded, a collapsed ventricle results on the side from which the choroid plexus has been removed, but the ventricle becomes greatly enlarged on the side in which the choroid plexus is intact. From these experiments *we have the only absolute proof that cerebrospinal fluid is formed from the choroid plexus. Simultaneously it is proven that the ependyma lining the ventricles is not concerned in the production of cerebrospinal fluid.*

EXTIRPATION OF THE CHOROID PLEXUS FROM BOTH LATERAL VENTRICLES FOLLOWED BY OCCLUSION OF THE AQUEDUCT OF SYLVIIUS

In a few dogs the choroid plexus was extirpated from both lateral ventricles and at the same operation or shortly thereafter the aqueduct of Sylvius was occluded. In these animals hydrocephalus developed and involved both lateral ventricles and the third ventricle (Fig. 8). There was, however, a pronounced retardation in the development of the hydrocephalus when compared with that which follows the introduction of a similar occlusion, but without a bilateral choroid plexectomy. Hydrocephalus develops because the amount of cerebrospinal fluid which is produced from the choroid plexus of the third ventricle and which cannot escape through the closed aqueduct of Sylvius, is still greater than the amount of the absorption which is possible from the three ventricles. The open foramina of Monro permit the fluid which is formed in the third ventricle to pass freely into and distend both lateral ventricles. We have tried removal of the choroid plexus of the third ventricle, but this has proved unsuccessful. The veins of Galen must be removed together with the roof of the third ventricle to obtain all the choroid plexus from the third ventricle. The animals always succumb to the effects of intraventricular hemorrhage if this operation is attempted. It would doubtless be possible (though we have not done it) to obliterate both lateral ventricles by occluding both foramina of Monro and later to obstruct the aqueduct of Sylvius, thereby producing enlargement of the third ventricle alone.

HYDROCEPHALUS FOLLOWING LIGATION OF THE VENA MAGNA GALENI

Hydrocephalus has often been attributed to an occlusion of the vena magna Galeni or sinus rectus, or both, but in most instances the evidence has been inconclusive. Hydrocephalus forming in this way would be analogous to ascites following stenosis of the inferior vena cava. In either instance the accumulation of fluid indicates an inadequate collateral circulation.

EXPERIMENTAL HYDROCEPHALUS

The vena magna Galeni drains the venous blood from the entire interior of the cerebrum, and these vessels, being largely terminal, have but little communication with the extracerebral veins. After the formation of the vena magna Galeni, however, numerous channels establish a free anastomosis between the intra- and extracerebral venous circulation. The basilar, superior cerebellar, temporal, internal occipital, posterior corpus collosal, and other veins bring the two systems into free communication.

Whether hydrocephalus results from venous stasis depends entirely upon the amount of collateral circulation which can develop. If both jugular veins are compressed in a dog, the amount of cerebrospinal fluid is immediately and rapidly increased. This increased production of fluid, however, disappears within a few minutes as the collateral venous circulation becomes established.

As early as 1768 Wyeth looked upon venous obstruction as an important factor in the production of hydrocephalus. Magendie (1825) records a case of thrombosis of the vena magna Galeni and sinus rectus. The symptoms were only of a week's duration, an interval too short to give a demonstrable dilation of the ventricles. As the determination of excess quantities of fluid postmortem is very unsatisfactory and untrustworthy, the diagnosis of early hydrocephalus may be questioned. In the vast majority of cases in which venous stasis is regarded as the cause of hydrocephalus, a tumor has been in the corpora quadrigemina, mesencephalon, corpus pinale, or elsewhere in the vicinity of the vena magna Galeni. Owing to the size of brain tumors, one is not justified in assuming that the hydrocephalus is due to a specific occlusion of the blood-vessels, especially since in the mid-brain the aqueduct of Sylvius soon becomes obstructed by tumors; and this we know always results in hydrocephalus.

Undisputed increase of cerebrospinal fluid from a vascular occlusion can be assured only when a pure vascular obstruction exists, as in thrombosis. The authentic cases in which thrombosis of the vein of Galeni or straight sinus has caused hydrocephalus are few, but apparently definite. Newman⁷ (1882) reports a case, and Browning⁸ (1887) another. Undoubtedly, others have been described but have escaped notice. A few cases of a sharply localized thrombosis of the vena magna Galeni with hydrocephalus are sufficient to establish the causative relationship.

Experimentally, we have been able to establish this point with accuracy. In a series of ten dogs we have ligated the great vein of Galen and the straight sinus in varying places. In a single instance hydrocephalus resulted, and in this case the obstruction was placed at the point of origin of the large vein of Galen (Fig. 10). In the remaining 9 cases the size of the ventricles

⁷ Newman, D.: Two Cases of Ventricular Hydrocephalus; One Due to Pressure on the Sinuses by a Tumor in the Cerebellum, the Other to Thrombosis of Galen's Vein. Glasgow M. J., 1882, iii, 161.

⁸ Browning, William: A Case of Internal Hydrocephalus Due to Disease (Thrombotic) in the Wall of the Straight Sinus. J. Nerv. and Ment. Diseases, 1887, xli, 260.

was not altered. In other words, hydrocephalus results when an occlusion of the great vein of Galen is located at its origin, but not when the obstruction is placed more distally or along the straight sinus. Above the origin of the great vein of Galen there is apparently sufficient venous collateral circulation to overcome the effects of the obstruction. In dogs, the vein of Galen can be fairly readily exposed at operation by retracting the occipital lobe and carefully dissecting the vein from its bed over the mesencephalon. For a very low occlusion, the splenium of the corpus callosum must be divided. The beginning of the vein of Galen can then be seen just above the pineal body. Ligation of the vessels by a ligature is difficult because of the depth of the wound. The same result is accomplished by compressing a small silver clip over the vessel at the desired point (Fig. 9).

The animal in which hydrocephalus resulted presented no symptoms which distinguished it from the others. The diagnosis of hydrocephalus was made solely from the post-mortem examination. The hydrocephalus developed very much more slowly than that following an occlusion of the aqueduct of Sylvius. In hydrocephalus resulting from venous stasis, all the cerebral ventricles and the aqueduct of Sylvius are enlarged. In gross appearance hydrocephalus so produced is exactly similar to that in the hitherto so-called "idiopathic" or communicating hydrocephalus. The aqueduct of Sylvius, the foramina of Monro, Magendie and Luschka, all become enlarged, because the accumulation of fluid is due to over-production, and there is no obstruction to localize the dilatation. This type of hydrocephalus is different from other chronic types. It is due to over-production of cerebrospinal fluid, whereas other forms are due to a diminished absorption. Possibly this type of hydrocephalus may subsequently be differentiated clinically, but we have had no case under observation. It must be quite rare, for from the pathological examinations of over thirty cases of hydrocephalus we have not encountered a single occlusion of the great vein of Galen or of the straight sinus.

CHANNELS FOR THE CIRCULATION OF CEREBROSPINAL FLUID IN THE SUBARACHNOID SPACE

Before considering the cause and the experimental production of the communicating type of hydrocephalus, it will add clearness to briefly consider the normal channels through which the cerebrospinal fluid is distributed. As heretofore mentioned, all the cerebrospinal fluid in the ventricular system must pass into the subarachnoid space through the three basal foramina of Luschka and Magendie. Of these foramina, not infrequently one or even two may be obliterated, and the third alone will maintain adequate communication. The arrangement of the channels of the subarachnoid space is in a general way that of the trunk and branches of a tree. The basal cisternæ—forming a water-bed under the brain stem and artificially subdivided into the cisterna cerebellomedullaris (cisterna magna), cisterna pontis, cisterna interpeduncularis, cisterna chiasmatis—are homologous to the trunk

of the tree. From these cisternæ, fluid is distributed along the major branches of the subarachnoid space which accompany the blood-vessels and traverse the sulci between the cerebral convolutions. The exact number and the relations of the smaller channels have not yet been worked out. The closure of large areas of the subarachnoid space over either cerebral hemisphere, apparently produces no general effects on the absorption of cerebrospinal fluid because the main channels are intact and there is a sufficient absorbing area remaining to easily compensate for this loss. If, however, the cisternæ are obliterated, the trunk is occluded and fluid cannot reach the branches of the subarachnoid space which spread over both cerebral hemispheres. There are no collateral channels which can reëstablish this circulation of cerebrospinal fluid, consequently cerebrospinal fluid cannot reach the cerebral subarachnoid spaces where most of the absorption takes place. An obstruction in the cisternæ is comparable to transection of the trunk of a tree. Whereas death of the tree results from division of the trunk, only local effects result from the destruction of many branches. Occlusion of the cisternæ results in hydrocephalus; many of its branches may be obliterated without hydrocephalus.

The circulation of cerebrospinal fluid can be strikingly demonstrated by substituting India-ink for cerebrospinal fluid in an anæsthetized dog. The ink follows the normal channels of the subarachnoid space; by sacrificing the animals at varying intervals of time after the injection, the various stages of distribution can be observed. Almost immediately all the cisternæ are filled with ink; the cerebellar subarachnoid space also rapidly fills, owing to its intimate relationship with the cisterna magna. Gradually filaments of ink fill the sulci over all surfaces of both cerebral hemispheres; the sulci radiate from the cisterna and appear to anastomose over the cerebral hemispheres. In a series of animals it required from 45 to 75 minutes to reach the most remote spaces along the longitudinal sinus. Very artificial results follow injections of fluids under pressure. Incidentally, if it takes such a long period of time to reach the longitudinal sinus, the hypothesis that absorption occurs through special structures along the longitudinal sinus is immediately vitiated, because normally the rate of absorption from the subarachnoid space is 20 to 25 per cent. an hour (by the phenolsulphonaphthalein test). Therefore, 20 to 25 per cent. absorption has already occurred before the longitudinal sinus has been reached by the dye. Such an hypothesis is also precluded by the fact that a considerable part of this absorption takes place from the spinal subarachnoid space.

THE CAUSE OF HYDROCEPHALUS WITH COMMUNICATION

The type of hydrocephalus in which no pathology has been found and which has been regarded as idopathic hydrocephalus is characterized by dilatation of all the cerebral ventricles and by a free communication between the ventricular system and the subarachnoid space. By the phenolsulphonaphthalein test this type of hydrocephalus has been shown to be caused by

a diminished absorption from the subarachnoid space. It will be remembered that fluid normally forms in the cerebral ventricles but does not absorb there; that absorption takes place only in the subarachnoid space. Therefore, the aqueduct of Sylvius and the foramina of Luschka and Magendie must be patent to maintain the balance between the production and the absorption of cerebrospinal fluid. In communicating hydrocephalus there is a greatly reduced absorption, despite a perfectly free communication. By the phenol-sulphonephthalein tests the absorption from the subarachnoid space has been shown to be only 10 per cent. in two hours, or about one-fifth of the normal rate of absorption from this space. The absorption of this dye from the ventricles in communicating hydrocephalus is also about one-fifth of the normal. The ventricular absorption, however, is but a reflection of the absorption from the subarachnoid space, since the absorption of ventricular fluid occurs only after it reaches the subarachnoid space.

In a recent paper⁹ this type of hydrocephalus was shown to be due to adhesions which obliterated the cisternæ. The adhesions were not present over the entire brain, but mainly at the base and around the incisura tentorii; that is, where the major effects of meningitis are usually distributed. Obliteration of the cisternæ or a circle of adhesions around the mesencephalon prevents cerebrospinal fluid from passing to sulci over the cerebral hemispheres. Absorption of cerebrospinal fluid is a general process, which takes place from the entire subarachnoid space. With the major part of the subarachnoid space mechanically eliminated by an obstruction in the trunk of the subarachnoid tree, the area in which absorption of cerebrospinal fluid can occur is limited to about one-fifth of the normal amount. Consequently, hydrocephalus results from a greatly diminished absorption. In reality, therefore, communicating hydrocephalus is caused by an obstruction, and differs from the so-called obstructive hydrocephalus only in the location of the obstruction. To disclose adhesions and obliteration of the subarachnoid space, the brain must be carefully removed and studied during its removal. A subsequent examination of the brain reveals but little, because the adhesions have all been liberated by removal of the brain, and the gross appearance of thickened pia-arachnoid is not striking after fixation. A striking demonstration of the location of the obstruction will no doubt result by injecting colored solutions into the spinal canal under minimal pressures. The colored injection mass, of course, will stop at the obstruction. This color contrast will be seen in one of the cases of experimental hydrocephalus which will appear in the following pages. A demonstration equally striking can be shown in the living by intraspinal air injections. These observations will appear in a subsequent paper.

These pathological findings are in perfect harmony with the appearance of the brain at operation. At operation, in both the obstructive and the communicating types of hydrocephalus, the sulci over the hemispheres are seen to be shallow and contain but little fluid. If the subarachnoid spaces

⁹ Soc. cit., *Am. J. Dis. Child.*, 1917, xiv, 424.

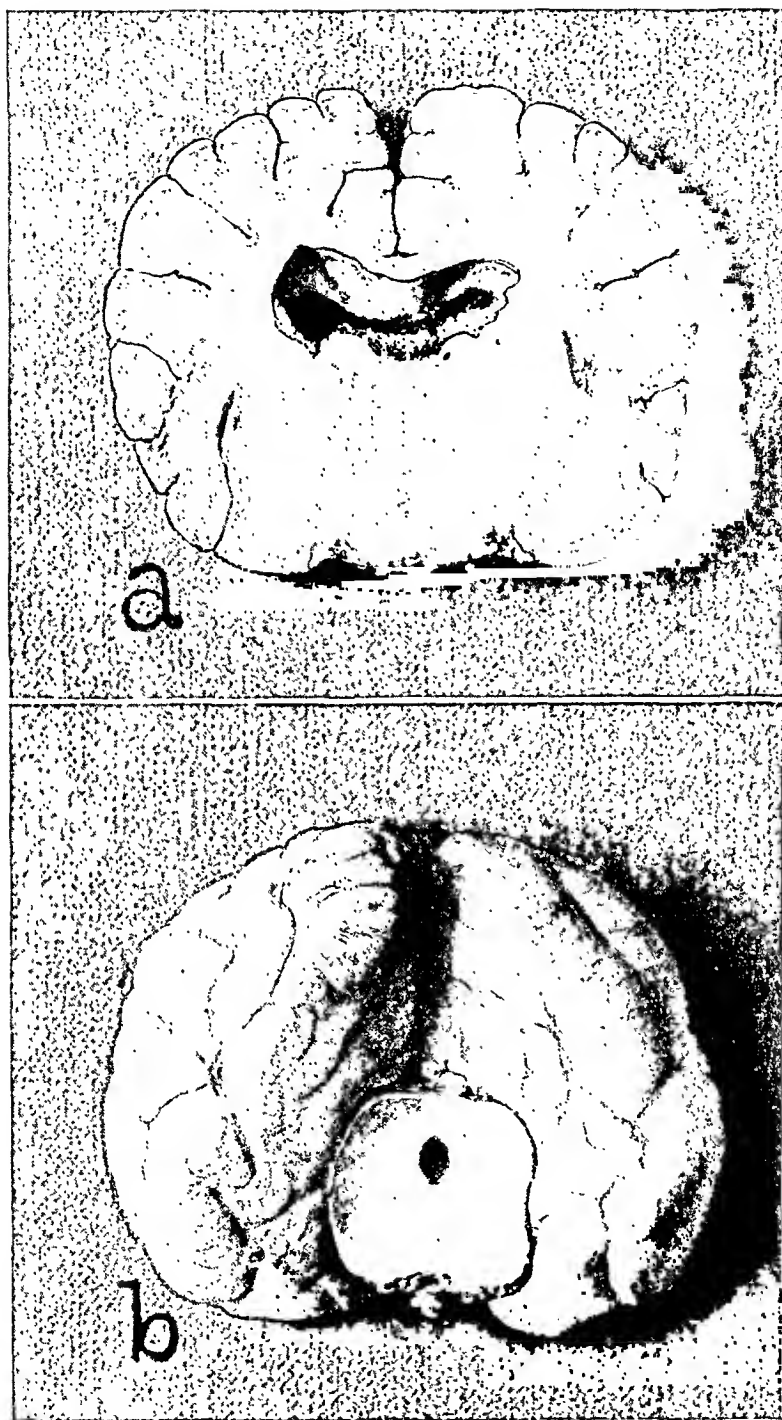


FIG. 10.—Hydrocephalus of three and one-half months' duration, resulting from a ligature on the vena magna Galeni near its origin. The aqueduct of Sylvius is also enlarged. This form of hydrocephalus results from an overproduction of fluid; all other forms from a diminished absorption of fluid.

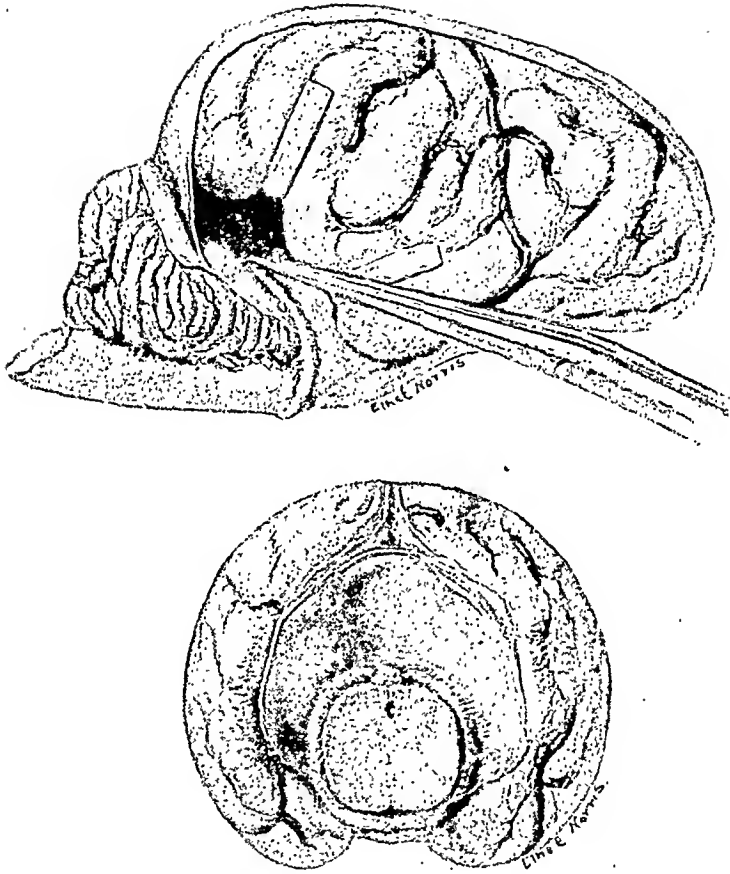


FIG. 11.—Drawings by Miss Norris to show method of placing a perimesencephalic band in position, and also to show its approximate location. The lower figure shows the band in place. Adhesions form between the brain and the gauze and occlude the cerebrospinal spaces, including the cisterna. "Communicating" hydrocephalus results from this procedure.

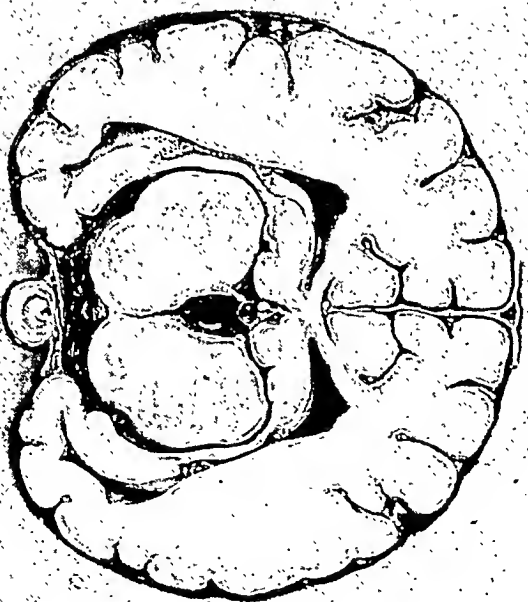
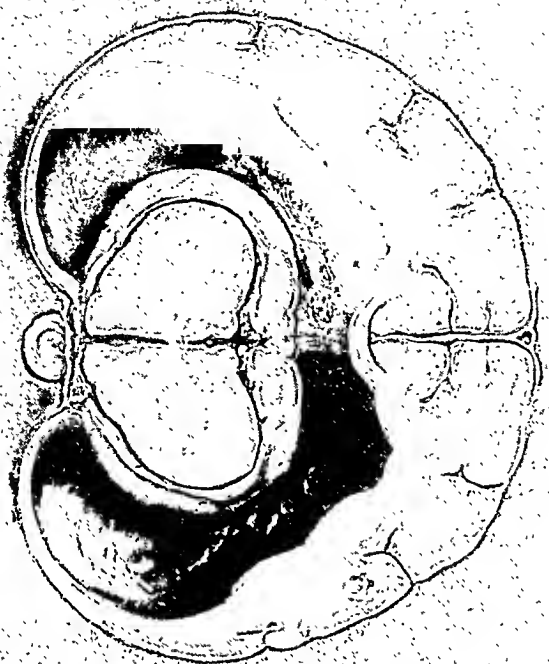


FIG. 12.—Section of a dog's brain in which hydrocephalus has followed the application of the band around the midbrain, as described in Fig. 11. The figure on the right is a section of a normal dog's brain at the same level. The hydrocephalus is of three months duration. These sections are taken from the brains shown in Figs. 13 and 14. Compare the ventricular dilatation with that in Fig. 10, in which the vein of Galen was ligated. Drawing by Mr. Brodel.

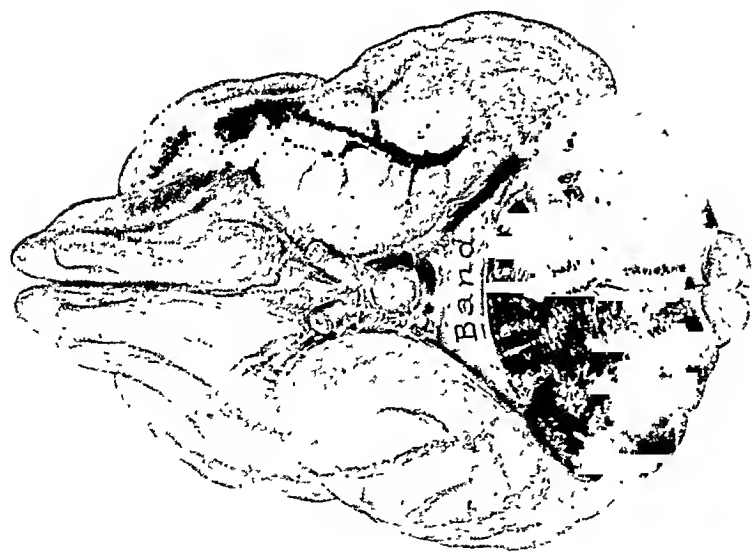


FIG. 13.—Drawings by Mr. Brodel, showing the result of injections of India ink into the spinal canal two hours before the animals were sacrificed. On the right the entire brain is colored black, as occurs normally. On the left the ink stops at the perimesencephalic band and can get no further. In other words the black area represents the amount of subarachnoid space reached by the cerebrospinal fluid—A, in the animal in which a band is around the midbrain, and B, the normal. Hydrocephalus of the "communicating" type results because most of the absorbing area of subarachnoid space has been eliminated by this extraventricular obstruction.

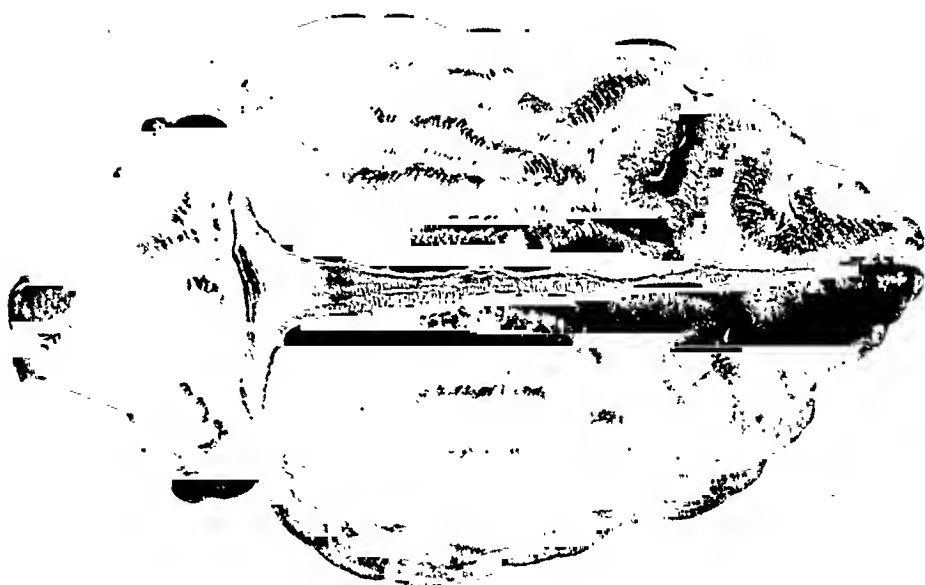
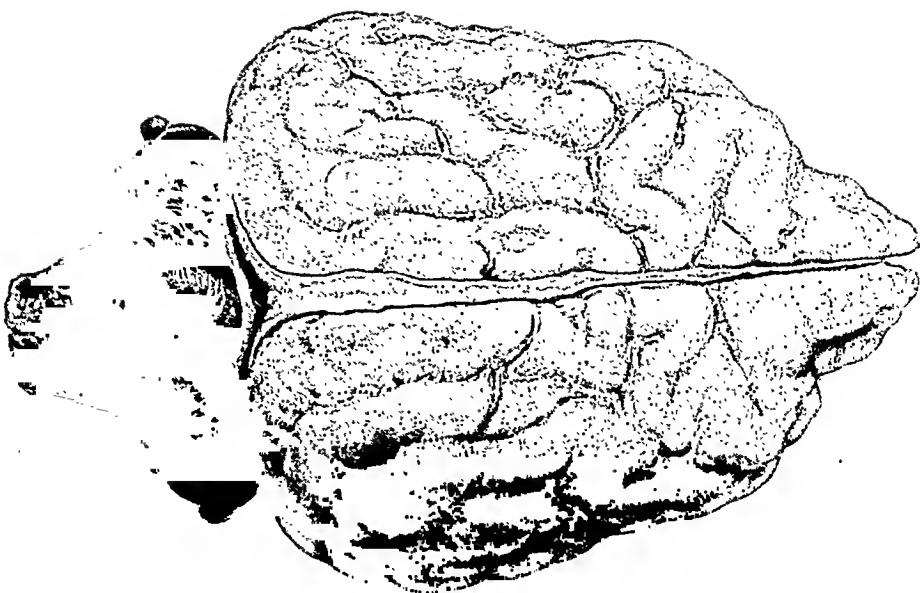


FIG. 14.—Drawings by Mr. Brödel of dorsal view of same brains as Figs. 12 and 13. It will be seen that the black ink stops at the tentorium cerebelli, it covers the cerebellum completely but none of the subarachnoid space over either cerebral hemisphere is reached. Section of these brains is shown in Fig. 12. Mr. Brödel has shown the light and dark surfaces of the brain in transverse sections also (Fig. 12). The ink filled the ventricles in the hydrocephalic brain but did not reach them in the normal brain (Fig. 12).

were not obstructed at the regions mentioned, fluid would accumulate in the sulci and cause their dilatation up to the point of obstruction, just as bile accumulates up to the obstruction in the common bile duct. There is but little fluid in the cerebral sulci because the barrier of adhesions has prevented the cerebrospinal fluid from reaching the cerebral hemispheres. As mentioned previously, the physiological tests (by phenolsulphonephthalein) show about one-fifth of the normal absorption from the subarachnoid space, apparently indicating a reduction in the subarachnoid space to one-fifth of its normal area.

THE EXPERIMENTAL PRODUCTION OF COMMUNICATING HYDROCEPHALUS

The absolute test that the pathological findings described for communicating hydrocephalus are correct lies in the ability to reproduce this disease in animals. The effects of meningitis are so diffuse that differences of opinion in the interpretation of the findings are permissible. A single, sharply defined experimental lesion eliminates speculation. The experimental methods which I have used were suggested by the results of the physiological phenolsulphonephthalein tests, and were developed before any pathological material had been obtained.

The object of the experiments is to eliminate the subarachnoid space above the incisura tentorii, and thereby to exclude the entire cerebral subarachnoid space from participation in the absorption of the cerebrospinal fluid. A glance at the intracranial topography will show that the only communication between the posterior and middle cranial fossæ is through the incisura tentorii, through which the mesencephalon passes. Except for this opening, the tentorium cerebelli acts as an impermeable diaphragm, which divides the cranial chamber into two cavities. We propose to produce adhesions around the entire circumference of the midbrain where it traverses the incisura tentorii (Fig. 11). This will obliterate by a circular band the subarachnoid space along the midbrain. The principal part of the subarachnoid space which will be obstructed by this procedure will be the cisterna. This cisterna is the part of the main trunk through which all the cerebrospinal fluid must pass. In other words, if the experiment is successful, cerebrospinal fluid cannot pass beyond the posterior cranial fossa into the middle, and thence subsequently also the anterior, cranial fossæ. *All cerebrospinal fluid enters the cisterna magna from the fourth ventricle*, but the experimental obstruction prevents it from passing into the cisterna interpeduncularis and cisterna chiasmatis. The cerebrospinal fluid therefore cannot reach the subarachnoid space which forms a mantle over both cerebral hemispheres. By eliminating the entire cerebral subarachnoid space the amount of absorption of cerebrospinal fluid should be tremendously reduced and hydrocephalus should follow.

This sharply defined area of adhesions can be produced by encircling the midbrain with a tiny strip of gauze which has been saturated with an irritant.

In the course of time a circle of adhesions forms between the margins of the incisura tentorii and the midbrain.

The technic of this procedure is as follows:

A subtemporal bony defect is made on each side and extending posteriorly to the tentorium (osseum in the dog) and inferiorly to the base of the skull. The temporal and occipital lobes are elevated on one side with a spatula until the carotid artery and third nerve are brought clearly into view. With a little additional elevation these structures are put on a stretch and the inferior surface of the midbrain can be seen. The third nerve is the most important landmark. The end of the gauze strand is passed under the mesencephalon to a point on the opposite side of the brain and emerging contralaterally just behind the third nerve. The operator then shifts to the opposite side of the table and elevates the other side of the brain until the third nerve is exposed on this side. The end of gauze will then be seen protruding and can easily be grasped with forceps. By gentle traction half of the strip of gauze is pulled under the midbrain, so that an equal length of gauze is on either side. The brain is then allowed to settle. The next step consists in retracting the occipital lobes forward, first on one side and then on the other, until the margins of the incisura tentorii can be distinctly seen. The gauze strip is then carefully inserted between the midbrain and the margins of this dural opening. The gauze is then in close apposition to the entire circumference of the midbrain and also of the dural edge. (Fig. 11.)

It has been found by experience that it is necessary to saturate the gauze with iodine in order to produce adhesions. Gauze not so treated becomes incorporated as a smooth foreign body, without adhesions, and has no effect upon the continuity of the subarachnoid space, and consequently there is no effect upon the distribution of cerebrospinal fluid. It is entirely probable that the irritant alone will produce the same result. In areas over the surface of the occipital lobe, which was unavoidably touched with the iodine, firm adhesions bound the tentorium to the brain. There has been no mortality incident to this operation.

Following the application of the perimesencephalic band, hydrocephalus develops almost as rapidly as following occlusion of the aqueduct of Sylvius (Fig. 12). That the subarachnoid space around the midbrain is obliterated by adhesions can be graphically demonstrated, by substituting India-ink for cerebrospinal fluid in the cisterna magna two hours before the animal is sacrificed. The ink granules are distributed through every part of the subarachnoid space which is open to the cerebrospinal fluid. By fixing the brain with intravascular formalin the ink granules are deposited, making a striking and permanent record. Normally, ink so introduced into the subarachnoid space will cover the whole brain in this period of time and a small amount may even pass through the foramina of Luschka into the fourth ventricle. When hydrocephalus results from a perimesencephalic barrier of adhesions, the ink cannot pass beyond this obstruction (Figs. 13 and 14). On the other hand, in the specimen of hydrocephalus which has resulted from the perimesencephalic band, all the dilated ventricles are full of ink because the foramina of Luschka (the foramen of Magendie is absent in the dog) are enlarged, permitting an easy backward passage of cerebrospinal fluid into all the cerebral ventricles. Although valves are not present, normally the approximation of the cerebellum to the medulla prevents more than a

trace of the colored fluid, which is in the spinal canal, reaching the ventricles. In experimental communicating hydrocephalus the presence of such a large amount of ink in the ventricles, together with a sharp color-line at the obstruction, is positive proof that there was ample opportunity for ink to reach the cerebral subarachnoid space if it were possible. This barrier of adhesions was therefore the sole cause of the hydrocephalus. The accumulation of fluid can be explained by assuming a reduction in the amount of the area for the absorption of cerebrospinal fluid. The dilatation of the aqueduct of Sylvius and presence of ink in the lateral ventricles also demonstrate that the circle of adhesions around the midbrain did not in any way constrict the aqueduct of Sylvius and thereby cause the hydrocephalus. The band of adhesions need not hermetically seal the subarachnoid space to produce hydrocephalus, for in one case a slight channel permitted a little fluid (ink) to trickle through for a short distance. It is entirely possible that if adhesions are not too dense such tiny channels may eventually dilate and modify the rate of development of the hydrocephalus or even overcome the effects of obstruction, and reaching the cisternæ beyond, reestablish the continuity between the cerebellar and cerebral subarachnoid spaces. Spontaneous cures of hydrocephalus not infrequently occur, and such a development could readily afford an explanation.

SUMMARY AND CONCLUSIONS

1. Hydrocephalus has been produced by placing an obstruction in the aqueduct of Sylvius. Dilatation of the third and both lateral ventricles results.
2. One foramen of Monro has been occluded; this is followed by a unilateral hydrocephalus.
3. If the choroid plexus of one lateral ventricle is completely removed at the time the foramen of Monro is occluded, not only does no dilatation occur, but the entire lateral ventricle collapses.
4. This is the only absolute proof that the cerebrospinal fluid is formed from the choroid plexus. At the same time it proves that the ependyma does not secrete cerebrospinal fluid.
5. If the choroid plexus of both lateral ventricles is removed, and an obstruction is placed in the aqueduct of Sylvius, hydrocephalus still results in the third and both lateral ventricles, but at a reduced rate. The fluid forms from the choroid plexus of the third ventricle but cannot escape into the subarachnoid space.
6. Cerebrospinal fluid forms in all the cerebral ventricles. It is absorbed almost entirely in the subarachnoid space. The sole communication between the ventricular system and the subarachnoid space is through the foramina of Luschka and the median foramen of Magendie.
7. The phenolsuphonephthalein test will prove conclusively whether the foramina of Luschka and Magendie are open or closed. Closure of these foramina invariably causes hydrocephalus.

8. Hydrocephalus follows ligation of the vena magna Galeni if the ligature is placed at the origin of this vein. Ligatures beyond or in the sinus rectus have no effect because there is sufficient venous collateral circulation.

9. The communicating type of hydrocephalus has been produced in dogs by a perimesencephalic band of gauze, saturated in an irritant which induces adhesions. This obstruction prevents cerebrospinal fluid from reaching the cerebral subarachnoid space where most of the cerebrospinal fluid is absorbed. The resultant diminished absorption of fluid results from hydrocephalus.

10. Hydrocephalus follows ligation of the great vein of Galen because of an overproduction of cerebrospinal fluid. In other types of hydrocephalus, both obstructive and communicating, the accumulation of fluid is due to a diminished absorption of cerebrospinal fluid.

CONCUSSION OF THE BRAIN

A STUDY IN DIAGNOSIS

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MANY pertinent facts can be brought out in the study of a single case, especially where you have the coöperation of specialists in various fields.

The following case of cerebral concussion is interesting, especially as a diagnostic problem. There was considerable doubt as to the diagnosis for some time. The patient had been seen by a number of men previous to his coming to our hospital, and different opinions had been given. The case was instructive in many ways. Expectant treatment in a hospital where a large staff is available for consultation is relatively a safer procedure than in private practice, of course.

CASE I.—H. C., private, 106 Inf. of Brooklyn, twenty-four years old, was admitted to U. S. A. Base Hospital No. 37, Dartford, Kent, England, by transfer from the 18th General Hospital, Boulogne, France, on August 10, 1918. There was only a brief history accompanying the patient. It is stated that he was a stenographer in private life. In the Army he had been a trusted runner, carrying important messages, when his regiment was in action. Except for a tendency to "catch cold" frequently, his previous history was negative.

We knew but little of the circumstances immediately connected with his injury, except that he was picked up unconscious on the battlefield, and remained in that condition for a number of hours. The only visible evidence of injury was a contusion on the forehead, and on the right wrist. He was able to open his mouth, but could not protrude his tongue, for some time after reaching the clearing station. There was no rigidity of the neck. When he became a little clearer, he complained of headache and dizziness.

A few days later, he began to notice marked tinnitus in the right ear. There appeared a foul discharge from this ear now for the first time. He had vomited only twice in all. He was nauseated. If he tried to sit up in bed, his dizziness was increased.

At the end of the second week he was still dull and apathetic. The least movement in bed made his headache much worse. For the past ten days there was blurring of vision: in fact, he said his vision had not been clear since the accident. He had lost much flesh and strength, and looked sick. Soon after his admission to my wards, I had the aurist see him. He said both ear drums were retracted; the right one showed an old perforation. An X-ray examination showed an old sclerosis of the right mastoid.

The discharge from his ear later stopped quite suddenly. His general condition remained about the same.

His pulse, respiration and temperature chart gave us no positive aid. Careful X-ray examination of the skull showed no evidence of fracture.

Numerous urinalyses were all negative; except on one occasion, when there was a faint trace of albumen.

A number of blood examinations were made. They were not particularly helpful. The following is a sample one: Red cells, 5,170,000; hæmoglobin, 65 per cent.; white cells, 7600 (small mononuclears, 49 per cent.; large mononuclears, 1 per cent.; polymorphonuclears-eosinophiles, 3 per cent.; polymorphonuclears-neutrophiles, 47 per cent.).

The Wassermann examination of the blood and spinal fluid was always negative. The spinal fluid was clear at all times. It showed no evidence of blood, and contained only two cells per mm.; globulin was negative. It was not under pressure.

A study of the pulse, temperature, and respiration chart for over a month was only of negative assistance. The temperature ranged from 97° to 100° F., except on three occasions, when it was between 96° and 97° F. The large majority of readings were between 98.2° F. and 98.8° F. His pulse during this period varied from 60 to 114; the majority of the times being between 74 and 88. It showed a greater variability than the temperature. It never showed a low rate on two days in succession. His respirations, while under our care, were always 18 to 20.

He continued to give us a great deal of concern. His apathy continued, he took no interest in his surroundings; yet before his accident he was a bright young man. Naturally the possibility of a brain abscess was always present, because of his general condition, and the otitis media, and the fact that the discharge resulting from it had suddenly stopped. When his sensorium became clearer, he spoke spontaneously of the appearance of a very disagreeable odor, of short duration, that preceded all his early attacks of dizziness. He did not have this phenomenon now. This worried us somewhat, as this symptom has been reported in cases of temporo-sphenoidal abscess.

The possibility of the case being one of dementia præcox was discussed, but not only the history and neurological examination, but the psychiatric analysis would eliminate this as a diagnosis. His lowered emotional tone, poor association of ideas, apparent indifference, lack of interest, and hearing of noises could readily be explained on physical grounds, due to cerebral concussion. The same holds true for his defective impressibility of memory, his poor past and worse present memory, and his inability to credibly perform intelligence tests, as we will show in speaking of the symptoms of cerebral concussion. He could not grasp the situation, nor understand clearly, nor hold the thread of conversation well—all due to his confusional state, incidental to the commotio cerebri—and not to any dementia præcox mechanism. He not only showed no real

volitional deterioration, nor a refusal to coöperate, as in dementia præcox, but rather gave you all the aid he could when he understood. In fact, he tried hard to aid the physicians. Another reason given in corroboration of his being a præcox, was that he was self-centred. But a careful psychological study of his personality showed him to be recessive in many of his tendencies; over-sensitive, and possessing a moderate inferiority-complex. So being self-centred was merely in keeping with his habitual attitude.

Nor was his clouding of consciousness as marked as we see in an infection-exhaustion psychosis. For he was only moderately confused, and showed practically no disorientation. Had he been suffering from a mild case of exhaustion psychosis one would have expected periods of changed moods, and irritability; and also a marked improvement at the end of six weeks. So to us it was evident that any emotional-volitional disturbance was a secondary and not a primary one.

He was given a careful neurological examination on a number of occasions. We will not give all the details of the examination, but only the more important facts. Though the ophthalmologist examined the fundi a number of times, there was never any papill-œdema. He continued to look ill; he seemed dazed, and was content to lie quietly, full dressed, on his bed. He appeared sad; though when spoken to, it cheered him somewhat. The vertigo was gradually disappearing. His chief complaint was a fairly continuous, severe, dull headache over the frontal and both temporal regions, which was made worse by exertion. There has been but little nausea of late. Except for the few times in the early days of his illness, there has been no vomiting. There was no hypertonia of the extremities. They, of course, were generally weak, in agreement with his general feeling of weakness. The deep reflexes were generally exaggerated—jaw, ankle, knee, and achilles—the left knee, and left ankle especially. There was a bilateral exhaustible ankle clonus—more marked on the left side. Abdominals and cremasterics were present and lively. No Babinski was elicited, but he had had a few lumbar punctures recently, and I have frequently found it absent, even when formerly present, after doing a puncture. There was a partial and irregular hemianæsthesia and hemianalgesia on the right side, more pronounced in the arm. It was very unlike the sensory disturbances seen in hysteria—not approaching the middle line in front, and in the back—not only was the limit of anæsthesia far away from the middle line, but it was very irregular. Position, pressure, and muscle senses were good. There was no asynergy. There was no paralysis, no atrophy, no spasms. There was no adiadochokinesis. He spoke in a low, slow voice, but there was no real dysarthria. He had a lateral nystagmus, more to the left. His vertigo had almost disappeared. Bone conduction was absent on the left side. No matter where you placed the tuning-fork on the skull, he heard it in the right ear. The purulent discharge from the ear had stopped now.

His pupils were equal, unduly dilated, and would not react to light: it was, at this time, over two weeks since atropine had been dropped into his eyes by the ophthalmologist. The right palpebral fissure was slightly smaller than the left. Slight equal contraction of the visual fields. In the early part of his illness, he had had diplopia, but there was none now. But he still has blurring of vision (existing even before atropine was put in the eyes).

His left labio-nasal fold was less prominent than the right, and the left side of the face showed less play of the muscles than on the right side. Both ear drums are retracted. Right mastoid shows an old sclerosis. Pulse, 72; temperature, 97.8°; respiration, 20.

He was under careful observation all the time. After the onset he continued to be apathetic, though his general condition was somewhat improved. He would sit in a chair for short periods, and walk about the ward. We tried to keep him as quiet as possible, for we had not ruled out a brain abscess. He had been sent over to us from France with the diagnosis "Vertigo; Derangement of the Internal Ear."

To us the two most probable conditions which were the cause of the patient's illness were cerebral concussion and a brain abscess, involving either the temporosphenoidal lobe or the cerebellum.

A simple neurosis was easily ruled out by the history and the neurological examination. (The term "shell shock," being a misnomer, was never used in the U. S. Army as a diagnosis.) To diagnose the condition as a psychoneurosis would have been extremely erroneous, for we were not dealing with a simple fatigue neurosis—a neurasthenia; and he certainly was suffering from something more than a mere hysterical reaction to a difficult situation.

The diagnosis of vertigo was only naming a symptom, and the diagnosis "Derangement of the Internal Ear" would certainly not explain his whole condition.

The clinical signs, including the X-ray examination, were against a fracture of the skull. As we well know the important thing in a fracture of the skull is the danger of injury to the brain—either immediate, or later from compression. Localizing signs are often absent. In our patient there was no slowing of the pulse, no high spinal pressure, nor blood-tinged fluid, no choked disc, and no vomiting (except twice in the early part of his illness). He did present some evidences of a possible fracture of the skull—as a disturbed sensorium and unduly dilated pupils which did not react to light. But, of course, we find these phenomena in other conditions. We know that involvement of the seventh, sixth, and third cranial nerves is frequent in fracture of the base; they, too, are involved in other conditions.

In estimating spinal fluid pressure, you take 70 to 120 mm. of water, or 5 to 8 mm. of mercury, as being the normal limits. Saying that 20 to 40 drops per minute is a normal rate of flow, is hardly a scientific and accurate way of estimating pressure, when we consider the various factors which might modify this rate. In this case

there was no increase in the pressure. In our experience, the examination of the eye grounds is a more valuable aid in diagnosing increased intracranial pressure than the estimation of the spinal fluid pressure. In this case there was no increased cell count, no increase of globulin, and the spinal fluid was not blood-tinged: which was all against a fracture of the skull; and also against an intradural hemorrhage.

So, too, the clinical signs and the course of the disease, and the negative spinal fluid, were against a meningitis, either traumatic or secondary to the ear condition. There was no rigidity of the neck, nor general muscular rigidity, and no Kernig sign. Nor was there any hyperæsthesia. The pulse, respiration, and temperature observations were also against a diagnosis of this condition.

It was necessary to rule out two conditions before we arrived at our final diagnosis; one of these was labyrinth disease. For at first hand there was an apparent Ménière syndrome. Ordinary labyrinth symptoms are dizziness, pain in the ear, tinnitus, deafness and vomiting. Then there was the possibility of a brain abscess.

In labyrinth disease the vertigo is due to involvement of the vestibular nerve. It is frequently of short duration. There is nearly always an accompanying nystagmus. Spontaneous nystagmus does not occur in labyrinthine shock. There was no rotary nystagmus, and no vomiting after the first few days, and but little nausea. In a true Ménière syndrome, you get severe attacks of nausea and vomiting. The tests applied did not indicate that the labyrinth was the cause of his symptoms. (Some of the French authorities say vomiting and nausea may be absent.) Unfortunately, the aurist left no notes about Bárány or pointing tests. The physical signs, of course, could not be explained by internal ear disease alone.

The discharge from the ear—he had a suppurative otitis media—was the suspicious element; it could be an etiological factor, but also in the case of a brain abscess, where it is the most frequent causative agent.

The possibility of a brain abscess—temporo-sphenoidal or cerebellar—was the thing that gave us the most concern. We naturally did not want to order a decompression unless it was really necessary, and likewise we did not want to delay ordering it if an abscess was present. The spinal fluid examinations were against an abscess. However, if it were deep-seated, with no meningeal involvement, one would expect the fluid to be negative. So, too, as for papilloedema, we know it is often absent in abscess, even if cerebellar. The failure to get any light reaction in the widely dilated pupils also concerned us; this lasted for three weeks, and then we got a sluggish response. About three weeks before, he had had atropine dropped in his eye by the ophthalmologist. He had complained of a blurring of vision since the early part of his illness. His fundi and optic nerves were normal. We thought that his visual disturbance was central in origin.

It is a well-known fact that an abscess in the temporo-sphenoidal lobe—the most common site of abscess from an otitic cause—frequently gives little or no focal symptoms; and sometimes but few general symptoms. Examination by X-ray did not aid us. In abscesses situated here, there may be certain disturbances of smell; or signs of indirect pressure on the pyramidal tracts; and in abscesses in the left lobe, there may be aphasic signs.

More than half of all brain abscesses are secondary to purulent diseases of the ear. The course is extremely variable—from days to years. A sudden cessation of a purulent ear discharge is often of grave significance. So our anxiety was not relieved when it occurred in this case. But at no time was his pulse consistently slow. Nor were there any temperature changes which were characteristic. The differential blood examinations were negative. There was no choked disc. The persistent headache, dizziness and lowered mental tension were suspicious phenomena.

The cerebellum is frequently the site of abscess, following middle ear disease. In this case there were certain signs suggestive of a cerebellar lesion; especially the vertigo, and a reeling sort of gait later on in the course of his disease. Were the vertigo a pure cerebellar affair, defective hearing and ear disturbances would not be present. Vestibular vertigo differs from cerebellar vertigo in that it changes with the position of the head, in any of the three planes. Cerebellar vertigo is rotary in character. The patient may fall toward the affected side. The gait is often tumbling: toward the side of the lesion. Asynergy and adiadochokinesis are usually present. (They were absent in this case.) Of course, besides an abscess, one had to think of small hemorrhagic foci, involving also the cerebellum, as the result of the concussion.

The cerebellum synergizes body movements. So a cerebellar lesion will cause symptoms due to asynergy—as tremors, adiadochokinesis, and nystagmus. Adiadochokinesis, if present, is corroborative; but, of course, it occurs in other than cerebellar conditions. In a cerebellar condition the gait is a trunkal one—the legs seem to follow the trunk. The shoulder or the pelvic girdle may be chiefly involved. You may notice swaying of the body when the patient is sitting. It might be well to remark here, that the cerebellar ataxic does not widen his base in walking (by separating his feet) as the tabetic ataxic does. It is a fact that without ataxia, of course, no cerebellar lesion can be diagnosed with certainty. At times you only get a hemiataxia, on the side of the lesion. Nystagmus is rarely absent in cerebellar disease, especially when looking to the side of the lesion. But spontaneous nystagmus is more of a bulbar than a cerebellar sign. Speech is drawling and slow. Headache in cerebellar conditions is usually occipital, and usually violent.

In a cerebellar dysarthria, the speech disturbance is due to ataxia of the tongue muscles. This was not the cause in our patient. The patient did show some unilateral facial weakness. In the beginning there was a paralysis of the tongue, but this soon cleared up.

CONCUSSION OF THE BRAIN

So taking all things into consideration, we felt that our patient's condition could not be explained as being due only to a cerebellar lesion.

Thus, by exclusion we concluded that we were dealing with a severe case of cerebral concussion. There were probably a number of scattered punctate hemorrhagic areas throughout the brain. It is true that most of the signs favored the right side of the brain.

In severe cases of cerebral concussion, the patient may be unconscious for hours or days. Blood may be, or may not be present in the spinal fluid. There may be retinal hemorrhages.

It might be of interest to note here a few of the results caused by high explosive shells. Marage, of Paris, says the velocity of the sound wave is 333 metres a second, under atmospheric pressure; but near an exploding shell, the speed of a shock wave is as great as 2000 metres a second. But this is only so for a short distance; for at 60 metres distance, the velocity is that of sound. In this danger zone of 60 metres, the pressure is increased as high as 200 kilograms to the square centimetre; but it lasts only $1/100$ of a second. Under this pressure, the blood is driven toward the centre, *e.g.*, the brain. It is checked, of course, by the capillaries—otherwise the fatal cases would have been much more numerous. Mott, of London, says that the force generated by a 17-inch shell equals 10 tons to a square yard. But the cerebrospinal fluid acts as a water cushion to the cord and brain.

In this patient we think there were numerous small hemorrhagic lesions in the brain. We also think that the ear condition existed in the rôle of a coexistent disease, and was brought into evidence by the shell explosion. But we do not think it was the cause of all of his symptoms and signs.

In severe cases of concussion, you may first get stupor, followed by apathy. Then you notice a marked disturbance of mental tension—difficulty in thinking, disorientation, memory poor for the past, and absent for the present, with nearly always a retrograde amnesia; difficulty in calculation, and slowness in all actions. Certain symptoms—as headache and a staggering gait, and a clouded sensorium—may persist for a long time. The history, physical signs and course show this to have been a severe case of cerebral concussion.

We felt we could readily rule out a fracture of the skull, and especially one with increased intracranial pressure. We never forgot the possibility of a brain abscess, which would have necessitated a decompression. Major Cyrus Pershing, of Denver, at that time neurologist to U. S. A. Base Hospital No. 29 in London, kindly saw the patient at my invitation, and we agreed on the interpretation of the case as one of severe cerebral concussion.

From a communication I received seven months after I sent the patient home from England, I learned that he had left the Army, that all he had at that time was a dry chronic otitis media; he had some feeling of weakness, and could not ride in subway cars.

TRAUMATIC FACIAL DIPLEGIA *

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ONE-SIDED facial palsy is surely of common occurrence. The synchronous involvement of both sides of the face by palsy is exceedingly rare. There is no way of determining the relative frequency of unilateral and bilateral facial paralysis, but in my investigation of the subject I found that many neurologists of large experience have seen no cases at all. As the most common cause of the condition, multiple neuritis easily comes first. In a very excellent article by Patrick,¹ the author added 29 cases, some of his own, and others from literature, to 19 cases previously collected by Laurans,² but Patrick believes that quite a number of the earlier cases reported are apocryphal. As I will show, similar doubt applies to cases reported as traumatic.

Facial diplegias have likewise been recorded as a result of diphtheria by Ross, 5 cases, and 4 after influenza. It is evident that quite a number have been reported as the result of double otitis media, and mastoid disease. In a few instances, bilateral so-called rheumatic paralysis of the face has been observed (Bell's palsy). A most interesting case of this nature was reported by Throckmorton,³ and in which there was an interval of six or seven days between the inception of the paralysis on the two sides.

A very interesting bilateral facial paralysis of syphilitic origin was entirely quoted in French by Sir Charles Bell.⁴ It was that of a young woman of sixteen, with a little tumor of the left frontal region. The day after her admission, November, 1828, the left side of the face was completely paralyzed, the tongue a little stiff, and speech embarrassed. The mouth was forcibly drawn to the right side. Eight days after the appearance of the left-sided paralysis, the same symptoms developed on the right side, the tongue was not affected. The eye-lids could not be closed, and the tears welled down on to the cheeks. The lips were flabby, and moved like curtains on expiration. The patient did not suffer in any way. One could hear her in fits of laughter, but she laughed as behind a mask. Under anti-syphilitic treatment this patient recovered. I present this case because it is interesting to note that it came from the Hotel Dieu, and the service of Dupuytren, who, sixteen years later, while in the amphitheatre of the hospital, himself suffered from a facial paralysis, which was due to a slight cerebral hemorrhage, that caused his death a year later. The great Cruveilhier made the autopsy.

Peripheral facial paralysis has likewise been observed in infants, as the result of difficult parturition and the use of forceps (Romberg⁵).

The earliest extensive report on facial diplegia appeared in 1901 by Sainton.⁶ Of the entire number of cases, only three were said to be of

* Read before American Surgical Association, June 18, 1919.

traumatic origin, namely, those of Gama, Romberg and Koslowski. The cases of Gama and Romberg must be excluded from the traumatic cases, since in neither of them is there any evidence of the involvement of both facial nerves.

By way of digression the case of Gama⁷ is interesting, for, according to the patient's statement, two bullets, coming in opposite directions, "whizzed" close to his head. "The shock of these bullets (the patient stated) distinctly struck my ears, and I became unconscious. I was roused from my lethargy by the pain which the Cossacks caused me while robbing me. When I recovered I was entirely devoid of speech, blood flowed from my mouth, from my nose and from my ears, but I recovered. With the rest of the prisoners I traversed Germany, Poland and Russia. There was a profuse bloody discharge from both ears, and this continued for eighteen months, when it finally ceased." Hearing was lost on both sides, but the lips lost none of their mobility. It is evident, therefore, that whatever may have been the primary lesions in this case, and whether or not they were produced by the vibrations of passing bullets, it is impossible to see anything in it like the traumatic paralysis of the portio dura of the seventh nerve.

A similar doubt must be placed upon the quotation from Romberg. The only case of double paralysis which I can find there was that of a man of forty, with a very decided venereal history.

It is probable that in rapidly fatal basal fractures, with general muscular relaxation, facial diplegias occasionally occur, and that they are overlooked because of the difficulty of recognizing them, and the apparent hopelessness of the cases from a prognostic viewpoint. At any rate, I have not seen such cases, nor am I cognizant of any reference to them in the literature at my command. The cases of traumatic facial diplegia are therefore very few. Indeed, I have been enabled to find records of only four. I believe myself justified therefore in giving brief abstracts of these cases.

The case of Koslovsky,⁸ then, is the only one of true traumatic facial diplegia which I have been enabled to find reported up to the outbreak of the war, and was reported in 1892.

CASE I. (Dr. B. C. KOSLOVSKY⁸).—Private J. J., while carrying logs from a boat to a landing, fell into the water, a distance about ten feet, and was struck by a log over the left half of the head. When brought into the hospital he was bleeding from both ears and nose and vomiting. Consciousness was retained, but speech was very indistinct. There was a large hematoma on the left side of the scalp. No other external injuries. Considerable headache. Temperature and pulse remained normal. The action of the pupils, negative at first, but later became normal in the right eye. Left pupil was dilated, and did not react to light. There was constant and marked diplopia. Hearing very much lessened on the right side, entirely lost on the left. The tuning fork could not be heard on this side. There is complete paralysis of both sides of the face.

All the symptoms detailed appeared simultaneously. After three months the paralysis of the face continued unchanged. The patient remained completely deaf in the left ear, while the hearing in the right was somewhat improved. Taste sense was at no time effected. When the patient was last seen it seemed probable that the condition as detailed at the last examination would be permanent.

Although there was no X-ray confirmation, the diagnosis of basal fracture could not be questioned. The injury to the facial nerves must have been above the geniculate ganglion from the undisturbed taste functions. It is probable that from the involvement of other cranial nerves the tear was above the entrance of the nerve into the internal auditory meatus of each side.

CASE II. (OPPENHEIM and HALLEZ⁹).—P. J., aged 28 years, infantryman, injured October 27, 1916, by the bursting of a large shell in close proximity. There was immediate loss of consciousness, followed by prolonged amnesia. He could furnish no details as to how he was hurt. Consciousness returned sixteen hours later. The primary report states that there were no external lesions. Double facial paralysis, bleeding from both ears, profuse nose bleeding, slight mydriasis on the left side. After a day or two he became semi-conscious again, and when he recovered complained greatly of nausea and vertigo. Epistaxis and bleeding from one ear returned again. He entered the otological service two weeks after his injury for "concussion of the labyrinth, injury to the tympana, with infection on both sides and facial diplegia." The face presents the appearance of a blank mask, without any expression, the creases of the forehead and of the face have completely disappeared, and there is a slight oedema of both cheeks. There is no diplopia, and visual activity is normal. Speech is a little slow, scanning and especially embarrassed by the pronunciation of the labials. Deglutition is normal.

It is interesting to note that after the first visit of the patient's wife, in consequence of a violent emotion, the man presented a complete mutism during four days. The cheeks are flabby, mastication is considerably embarrassed because foodstuffs fall between gums and the cheek. The soft palate is lifted normally, and there is no deflection of the uvula. The sensibility of the tongue is conserved, but the sense of taste is abolished in the anterior two-thirds.

The electrical examination made in January, two months after the injury, shows a degeneration reaction of the seventh pair, a little more marked on the right than on the left side. The hearing on the right side is diminished, and there is an otitis media. On the left side hearing is quite gone, and there is suppuration of the middle ear. The facial and auditory nerves seem therefore to have been involved, but no others are in any way injured.

The lumbar puncture made in January showed a clear lymphoid fluid, with a little more albumin than normal, and a scarcely appreciable increase of cellular contents. During the months' sojourn in the service, the patient improved considerably, the eyelids could be partially closed, and the forehead slightly furrowed. As to the cause of the paralysis, the authors are in doubt. It might have resulted from a fracture through the petrous portion of both temporal bones, or it may have resulted from an immediate intratubal concussion. It is possible also that the injured man was thrown backwards and sustained a fracture of the base, through both temporal bones. In favor of this hypothesis are the nose-bleed, the repeated bleeding from the ears and the prolonged coma. In support of the possibility of the shock of the explosion alone causing the damage in the petrous portions of the temporal bones without fracture, the authors allude to two men, who, without any trace of external injury, or even of a fall, presented, as a result simply of concussion, a total unilateral facial palsy.

CASE III. (CHATELIN and PATRIKIOS¹⁰).—The case, when presented, was one of six weeks' duration. There was a total double paralysis of the peripheral type. On the left side the paralysis is absolute, while on the right there is an indication of very slight movement, in an effort to close the eye. The aspect of the face is characteristic. The forehead is entirely without wrinkles, naso-labial folds have disappeared, the lips are half open, and the saliva drools from the mouth. Speech is almost incomprehensible. Mastication is very difficult. Electrical examination shows complete reaction degeneration on both sides. The diplegia was the result of an accident. The wounded man was about to unload a heavily loaded wagon, when it was suddenly propelled backwards

TRAUMATIC FACIAL DIPLEGIA

and his head was caught transversely between the wall and the wagon. Released at once the man bled from the left ear. The diplegia manifested itself at once. For several days the face was very much swollen, and he had many ecchymoses in the temporo-malar region. Eating was uncomfortable on account of the trismus. This, however, disappeared in a few days. The writer believes that the facial nerve was injured on both sides by a transverse fracture at the base of the skull, even if there were no actual symptoms of injured lesions of the organ of audition. It appears to the writer that in the absence of loss of taste and of the radiographic evidence of fracture of the base, in this case, it is more likely that underneath the ecchymoses described in the temporo-malar region, the facial nerves had been injured by compression after their exit from the stylo-mastoid foramen.

CASE IV. (L. MARCHAND¹¹).—Soldier, 22 years old, was thrown from an automobile truck on August 22, 1917. He has no recollection of how the accident occurred. There is immediate bleeding from both ears, epistaxis and bilateral facial paralysis. In the temporal region there is a contused wound.

The patient was unconscious for forty-eight hours.

Diagnosis.—Fracture of the base of the skull. On the morning following admission there was a considerable palpebral and subconjunctival hematoma; there was also a hematoma at the nape of the neck. A lumbar puncture was made on the day of the accident, but in the original report no result of the examination is given. During six days the punctures were repeated. He was admitted to the Neurological Center of Bordeaux, on the 4th of December, 1917, when the facial paralysis continued. The record states that the movements of the face are nil on both sides. The patient cannot laugh, cry or whistle. Speech is difficult, on account of the inability to pronounce the letters B, P and M. Swallowing is normal, but to drink the patient must hold his head backwards to prevent the liquids from running out of his mouth. The sense of touch and pain is normal, both in the tongue and the face. Salt, acids and sweets are not felt in the anterior two-thirds of the tongue on the right side, but the taste for bitter things is normal on both sides. In March, of 1918, there was some voluntary movement of the lower portion of the left side, and the left eye could be completely closed. There was still a loss of gustatory sense on the left side. On the right side the paralysis presents no improvement.

The following is the one I have been privileged to observe:

CASE V.—Miss E. K., aged twenty-two years, injured January 4, 1919, in a street-car accident. On entering the First Surgical Service at the Cincinnati General Hospital she was unconscious and bleeding from both ears. The coma, which was not deep, continued for over an hour, and was followed by vomiting. There were two general convulsions, lasting for about five minutes. Both convulsions were preceded by twitching of the right eye-lid, and the entire half of that side of the face. During ten days following the accident the patient suffered from severe headaches, with pain in the ear and nausea. Pulse on entrance varied between 82 and 90, and was of good quality. The temperature was normal.

On admission there was a slight contusion in the right frontal region, and an incised wound 5 cm. long in the midline. There was a complete left-sided facial paralysis, and a slight ecchymosis on both mastoid regions.

On the morning of the third day after admission, the right side of the face was found to be completely paralyzed. The neurological ex-

amination at this time by Dr. Hoppe shows that the patient was oriented for time and place. The facial expression is one of indifference, and there is a decided mental sluggishness. The right pupil is slightly larger than the left, and the left external rectus a little weak. All other eye muscles are normal. The paralysis of the face is complete, the patient being unable to close either eye in the slightest, to move her lips or the wings of the nose. The face is mask-like, and the lips flap loosely on expiration. Owing to the inability of using the lips, speech is very indistinct. Facial expression which would result from an emotion is only expressed by the eyes.

Ear examination by Dr. Iglauer shows tinnitus in the right ear. Both drums are intact, there is no spontaneous nystagmus. Weber to the left. Bone conduction is normal. Whispered voice is heard at 8 feet in both ears. A lesion of the eighth nerve on either side can therefore be excluded. There is no hyperacousis.

An examination of the tongue shows that it can be protruded normally, in the middle line, and moved from side to side. There is no deflection of the uvula. The sense of touch is normal. The gustatory sense is completely absent on both sides of the anterior two-thirds of the tongue. The patient is unable to taste sweet, vinegar, sugar or bitter things.

The X-ray examination and the stereoscopic plates show an oblique fracture through the cranial base, running through the left mastoid process into the petrous portion of the temporal bone.

According to the subsequent history the paralysis disappeared from the right side of the face in the course of two or three weeks, and during the next two months it had disappeared entirely from the left side. The muscular control returned first in the lower part of the face. First, a slight motion of the angle of the mouth, then of the nose and lastly of the eye-lids. This progress of recovery occurred upon both sides. It is interesting to note that the presence of a partial paralysis and the manner of retrogression of a paralysis may be explained on the theory advanced by M. Moure, namely, that the facial nerve in the Fallopian canal is composed of two sets of fibres—the one peripheric or superficial, which constitutes further along the supply of the lower facial group of muscles, the other central or deep, and which innervates the upper muscle group. The superficial fibres would, therefore, be more exposed than the deeper ones to irritation and compression coming from the outside, and, therefore, there would be a slower return of the muscular power in the lower facial area. So far as I know, there has been no anatomic demonstration of this theory. In fact, the case reported substantially contravenes the hypothesis as set forth. The same lack of confirmation is made manifest by the case of M. Marchand. Nevertheless, the anatomic question is one of exceeding interest, and would well merit further study.

An interesting point is that in this patient there were two convulsions, each beginning with twitching of the right side of the face. This might lead to the belief that there had been some irritative lesion

of the right nerve in the canal before the hemorrhage had set in. The slight weakness of the left external rectus could not be accounted for, and disappeared very rapidly.

Remarks.—It is very evident that the lesion in this case, on each side, was in the Fallopian canal, below the geniculate ganglion, and at a point above where the chorda tympani is given off. It was also below the point where the nerve to the stapedius is given off, since there is no record of hyperacousis.

Although there was a fracture across the base of the skull, through the mastoid and petrous portion of the temporal bones, as shown by the ecchymosis behind the ear, it is quite certain that neither nerve was severed. Of the right nerve one can be sure of this, since the paralysis did not manifest itself until two days after the injury. Hemorrhage only could have accounted for this late occurrence. On the left side the paralysis was instantaneous, but since it completely and speedily recovered, it is likely that here also there was only a contusion with hemorrhage. Where there has been a complete severance in continuity, recovery after fracture is very uncommon, and if it does occur, does so only after the lapse of many months.

It is evident from the above that traumatic facial diplegia is an exceedingly rare condition, since I have been enabled to get only four other cases from the literature at my command. It is remarkable that all of these cases recovered, since, with the possible exception of two of the cases, all of them presented evidences of basal fracture, and in one of these the basal fracture could not be positively excluded. In Case II, there is a possibility that the peripheral portions of the nerve, after their exit from the stylomastoid foramina, were injured, since there was no record of the loss of taste.

In none of the cases recorded was a decompressive operation indicated in the judgment of the surgeons in charge. With the exception of one of the cases, on each side the lesion was in the Fallopian canal, although in our case hearing was not involved, whereas in some of the cases it is evident that from the loss of hearing the eighth nerve was included in the damage, either as a result of hemorrhage or of concussion of the internal ear.

Since the above was written, I have received a communication from Dr. Ernest Sachs, who reports the following case of traumatic facial diplegia from the Barnes Hospital.

CASE VI.—The patient, aged sixteen, was admitted October 11, 1912. Motorcycle accident. There was bleeding from the right ear and the nose. No fracture could be made out by palpation. K. K. very active. No ankle clonus, and no Babinski reflexes present. The left eye somewhat dilated. Does not respond to light. Slight exophthalmos of the left eye. Pulse 138. Blood-pressure 135. Vessels in the eye grounds are tortuous. Lumbar puncture could not be made. There is complete external rectus paralysis on the right side and a slighter one on the left. The orbicular muscle about the mouth cannot be used. He is unable to pucker his lips, nor can he whistle. It is evident that there is a bilateral facial involvement. Neither facial nerve reacts to

faradism, and it is only with the strongest possible current that one can get contractions. Does not seem to taste quinine on the anterior part of the tongue, but does on the posterior. Salt and sugar are both recognized. When the patient sleeps, both eyes are completely closed, while when awake and told to close them he cannot do so. X-ray plates do not show a basal fracture. Just before the patient was discharged on the 11th of October, it was noted for the first time that he was beginning to gain some use of the muscles about the mouth on the left side.

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A CLINICAL STUDY OF NERVE ANASTOMOSIS *

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THIS paper represents the results of forty-one cases of nerve anastomoses performed in the Mayo Clinic up to January 1, 1917. Cases in which post-operative records are shorter than sixteen months are not included in the report.

In 1852 two theories of nerve regeneration were advanced; one, that the axons grow out from the central end, that complete degeneration takes place from the severance of the nerve proximal to the node of Ranvier, and distally through the entire peripheral nerve; and two, that the axons do not degenerate in the peripheral stump after they have been separated, and that the fusion with the central axon and the development of the new myelin sheath about it is necessary to enable an axon to functionate.

The modern work on the regeneration of nerves may be said to have been begun by von Büngner in 1891, followed by Howell and Huber in 1892, by Ströbe in 1893, and by Huber in 1895. Von Büngner called attention to the nucleated protoplasmic bands which have been so conspicuous in the histogenesis of regenerated nerve fibres. He emphasized the fact that the nuclei of the neurolemma increase in number and that the protoplasm accumulates about them. Howell and Huber observed the presence of protoplasmic bands (Bandfäsern) but regarded them as embryonic nerve fibres capable of receiving and transmitting impulses. Ströbe was able to demonstrate the outgrowth of axons from the central end but believed that the myelin sheath was formed as a continuation of the old sheath. Huber, working with Ströbe's technic, was able to show that the axons grew from the central stump and in some cases entered the substance of the protoplasmic bands in the distal segment. Ranson in 1912 presented his work on the degeneration and regeneration of nerve fibres, in which he verified the investigations made by Waller in 1852, and gave a clear description of the processes of degeneration and regeneration, as well as a thorough review of the literature. Kirk and Lewis in 1915 and 1916 also presented a very complete histologic study of nerve regeneration.

Nerve anastomoses have been accomplished by the use of methods as follows: Létiévant made flaps from the central or the peripheral stump of the divided nerve, or from both the central and peripheral stumps. If it was impossible to bring about an immediate approximation of the

* This material was studied in the preparation of a thesis submitted to the Graduate Faculty of the University of Minnesota in partial fulfilment of the requirements for the Degree of Master of Science in Surgery, June, 1918.

nerve ends, various materials were used to bridge the gap. Assaky recommended a bridge of catgut between the severed ends, Vanlair used decalcified bone tubes, Payr magnesium tubes, Forssman celluloid tubes, Lotheissen gelatin tubes, Foramitti the hardened arteries of the calf; Denk, Döpfner, Kredel, and Kirk and Lewis fascia lata tubulization, Corbett and Beckman vein tubulization, Sherren Cargile membranes, Auerbach galalith, and Assaky and Hubner nerve transplants. Feiss used the fusion method of overlapping the ends and ligating them with silk or chromic catgut.

All of the various methods of nerve anastomosis have been discarded except: (1) the flap method, (2) the fusion method, (3) fascial tubulization, (4) vein tubulization, (5) Cargile membrane tubulization, (6) nerve transplantation, and (7) end-to-end anastomosis.

The nerve flap method, described by Létiévant, has been used extensively by operators in general surgery. Their patients improve, but the degree of improvement is not accurately stated in their reports.

The fusion method was advocated and tried out experimentally by Feiss, who felt that regeneration depended more on the regenerating scar than on the approximation of the nerve ends.

Fascial tubulization was brought to our attention recently by Kirk and Lewis, who presented a study on experimental tubulizations as well as reports of clinical tubulizations. However, the fascia lata had been used by former workers, for example, Denk, Döpfner, and Kredel.

Vein tubulization was described by Corbett, who employed very much the same technic that Kirk and Lewis used in their fascial tubulization, namely, removing a large portion of vein, dividing it longitudinally and placing it around the severed ends of the nerve as a piece of fascia. Beckman used the resected vein as a closed tube, slipping the cuff of vein over one of the nerve ends prior to anastomosis and then bringing the vein back over the intervening gap, and surrounding the cylinder of silk.

Sherren recommended the use of Cargile membranes, the fixed peritoneal membranes of the ox, for the purpose of tubulization.

Nerve transplants were suggested and tried experimentally by Philippeaux and Vulpian. They were used by Assaky in clinical cases and by Huber in a series of experimental cases. Huber reports twenty-six experiments made on the foreleg nerves of dogs. Ten were observed for a period of time long enough to permit regeneration of the peripheral stump, five of which presented complete and four nearly complete return of function.

It is rather difficult to classify the results of the various operations reported in the literature on the subject. Speiser in 1902 collected 208 cases of nerve suture; these combined with 129 cases collected by Schmidt make 337. Two hundred and thirty-four patients (66.5 per cent.) obtained good results, 53 (15.5 per cent.) obtained partial relief, while 60 (18 per cent.) were not improved by the operation.

Sherren reported 4 (50 per cent.) successful cases in 8, by the autotransplant and homotransplant methods, and Huber reported 37 per cent. of successes in 22 cases of heterotransplants.

Oberndörffer reported 167 cases of nerve sutures, in 96 of which operations were done the day after the injury. Good results were obtained in 38 per cent., fair results in 35 per cent., and failures in 16 per cent.; the results in 11 per cent. were unknown. In cases in which operations were done from two to seven days after the injury, good results were obtained in 35 per cent. and fair results in 52 per cent.; the results were unknown in 15 per cent. In the operations done from eight to fourteen days after the injury good results were obtained in 57 per cent. and fair results in 43 per cent. In operations from three to four weeks after the injury good results were obtained in 56 per cent., fair results in 32 per cent. and failures in 12 per cent. In operations from five to eight weeks after the injury good results were obtained in 44 per cent., fair results in 25 per cent., and no improvement in 31 per cent. The statistics with regard to nerve suture, compiled by different men, show that good results were obtained in 70 per cent. of the cases.

HISTOLOGY

A brief review of the histology of peripheral nerves will call attention to the fact that the fibres of medullated nerves arise from the anterior horn cells and join the fibres from the dorsal root which contains both medullated and non-medullated fibres (Ranson). The non-medullated nerve fibres have their origin in small ganglion cells in the dorsal ganglion, and have axons surrounded by a neurolemma without myelin. The medullated nerve fibres have an axilemma next to the axis cylinder; this is surrounded by the myelin sheath, which in turn is surrounded by a neurolemma (Schwann's sheath). The myelin is divided into segments by the nodes of Ranvier. Elongated cells which are of the utmost importance during the process of regeneration are associated with Schwann's sheath.

Degeneration and Regeneration.—Immediately following the division of the nerve, abortive regenerative processes take place; that is, the axis cylinder in both the proximal and distal stumps (more pronounced in the proximal end) undergoes fibrillar disintegration with an outgrowth of fibrillæ within the neurolemma. This process extends back for a distance of about three millimetres and begins within the first thirty-six to seventy-two hours following the severance of the nerve. At the same time the nuclei associated with the Schwann's sheath start a process of hyperplasia which begins with enlargement of the nucleus and a granular deposit in the cytoplasm. The wallerian degeneration begins about the third day and is quite complete on the twelfth day, except for the resistant axons and the myelin granules that may be seen for several weeks. This process consists of a granular disintegration of the axon in the distal end

and of the axon in the proximal end up to the first node of Ranvier. The myelin begins to disintegrate and forms droplets of fat within the neurolemma, thus giving a positive black stain with Marchi's method, whereas the normal myelin gives a yellow stain.

The regenerative process is continuous with the degenerative process; first, the nuclei of Schwann's sheath multiply very rapidly and fill the empty lumen of the neurolemmal sheath in the distal end as well as the sheaths from the site of severance to the first node of Ranvier; then, if the intervening gap between the severed ends is not too long, or if it is protected by some form of tube, these cells will send out protoplasmic bands of gelatinous appearance, which fill the intervening gap. Simultaneously the axon sends out numerous neurofibrillæ, numbering from five to fifteen, which grow downward through the mass of protoplasmic bands, and, if the gap has been bridged by these bands, they follow the bridge and enter the distal nerve segment. It is not uncommon to find two or three axons following a single protoplasmic band. Many of the neuraxons, however, will fail to enter the distal nerve segment and will produce an oval enlargement at the site of anastomosis, known as a neuroma.

The protoplasmic bands and cells arising from the neurolemmal sheath not only assist in keeping the lumen of the distal segment open and bridge the intervening gap between the nerve ends, but also apparently they arrange themselves and act as a reticulum, forming the mesh work in which the myelin is deposited, enabling the nerve to complete its process of regeneration. The following outline is quoted from S. Walter Ranson:

"Early Changes in the Distal Stump.—1. Degeneration of the medullated fibres and formation of nucleated protoplasmic bands. 2. Degeneration of the non-medullated fibres and the formation of nucleated protoplasmic bands. 3. Abortive autogenous regeneration in the distal stump.

"Early Changes in the Proximal Stump.—1. Changes in the non-medullated fibres; early abortive regeneration; cellulipetal degeneration; formation of new axons. 2. Changes in the medullated fibres; formation of a zone of reaction; fibrillar dissociation; early branching of the axons in the immediate neighborhood of the lesion; formation of lateral branches at some distance above the lesion; formation of fibre bundles and skeins.

"Mechanism of the Regeneration of Nerve Fibres.—1. Proliferation of axons in the central stump. 2. Penetration of the new axons through the scar. 3. Utilization of the protoplasmic bands as pathways for the new axons in the distal stump."

CLINICAL FINDINGS

All the patients had preoperative neurologic examinations, and many returned for subsequent examinations. We secured data of the patients, who were unable to return, by correspondence and by the coöperation of local physicians.

Nine facial anastomoses were made (five females and four males). The average age of the patients was twenty-four years. Eight (89 per cent.) of the nine patients have been examined at intervals following operation, or they have reported by letter. The average duration of the injury before the anastomosis was made was twenty-six months. The three patients who were operated on within the first year following the injury showed improvement of from 60 to 85 per cent. in return of function. The patients operated on at varying periods of time up to five years showed an improvement up to 50 per cent. of function. One patient, with a fifteen year history, failed to reply to the "follow-up" letter. The injury of the nerve in two cases was due to a mastoid operation and in seven cases to a lacerated wound in the region of the seventh nerve. In eight cases the anastomosis was to the spinal accessory, in one case to the hypoglossal. In eight cases end-to-end anastomoses were made, three of which were covered with fascia, four with vein, and one was left uncovered. In one case the anastomosis was by the Feiss method, the nerve ends were overlapped and ligated with silk. The average time before improvement was noticed, following the anastomosis, was seven and nine-tenths months; the average time for maximum improvement to be reached was eighteen and one-half months. The average amount of motor return estimated by quantitative examination of the power and control of the facial muscles, was 71 per cent. of the normal function.

In summing up the results, it is found that in 89 per cent. of the patients heard from, all of whom had improved, the average amount of improvement was 71 per cent., and in this group there were no failures nor indeterminate results, no infections and no deaths.

Seven ulnar anastomoses (one female and six males) were made. The average age of these patients was twenty and four-tenths years. Five (71 per cent.) were heard from or were studied following operation. The average duration of the injury before the anastomosis was six months, the shortest six weeks, and the longest twelve months. Two of the injuries were associated with fractures of the elbow and two with lacerated wounds of the forearm. Six of the anastomoses were made with silk sutures and one with chromic catgut. Three were covered with fascia. In five cases the apposition was direct, without a gap; in two the gap, which was an inch long, was covered with a tube of fascia lata. The average time before improvement was noticed in these cases was ten months; the average time before maximum improvement was noted was sixteen and two-tenths months. The amount of maximum improvement in the patients who reported was 63 per cent. of the sensory, motor, and trophic functions. There were no failures nor indeterminate results, no infections, and no deaths.

One radial anastomosis was made. The patient, a man aged twenty-four years, was operated on two months after the injury. The anasto-

mosis was done with silk. Unfortunately, we have not been able to obtain a report from this patient since he left the clinic.

Seven median nerves were repaired. All the patients were males, their average age was twenty-three years. Six (85.7 per cent.) of these patients have been heard from, or have been studied following operation. The average duration of the injury before operation was eighteen months, the shortest six weeks, the longest four years. Five patients were operated on within the first year, two gave a four-year history; all the injuries were due to lacerated wounds. In three cases the anastomoses were made with silk, in three with chromic catgut, and in one a plastic operation was done. In five fascia covering was used, in two the nerve was left uncovered. Direct apposition was obtained in five cases; in two a gap of one inch separated the severed ends. The average time

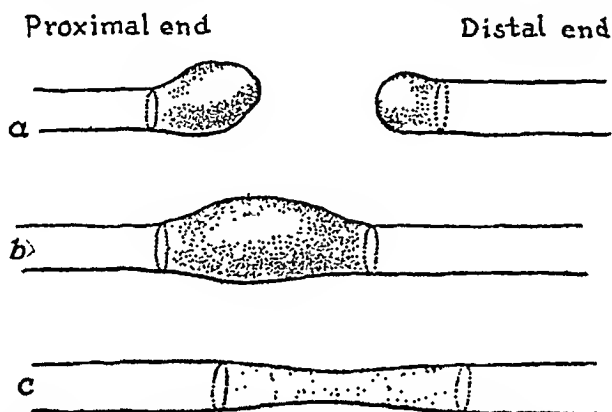


FIG. 1.—Clinical findings in peripheral nerve injuries, (a) severed nerve with neuromas and lines indicating the level of resection prior to anastomosis, (b) neuroma due to trauma without severance of the nerve, (c) constriction of nerve due to scar tissue or callus.

before improvement was noticed was ten and nine-tenths months, the average time before maximum improvement was reached was twenty-one months, with 72 per cent. return of the sensory, motor, and trophic functions. There was, therefore, in the patients heard from, improvement in 71 per cent., one failure, no indeterminate results, no infections, and no deaths.

Ten musculospiral anastomoses were done; all the patients were males, whose average age was thirty-six years. Nine (90 per cent.) were heard from after operation. The average duration of injury was twenty-eight months, the shortest two and one-half months, the longest twelve years. Nine of these injuries were associated with fractures of the humerus; one was due to a lacerated wound. Seven of the anastomoses were end-to-end, with silk and chromic catgut sutures. In two the operations were plastic; a segment of the proximal end was turned down. In one case the nerve was freed from adhesions. In seven cases the anastomoses were covered with fascial tubes; in four of these a gap of from one-half to one and one-half inches separated the ends of the nerves. The average time before improvement was noticed was twelve months; the

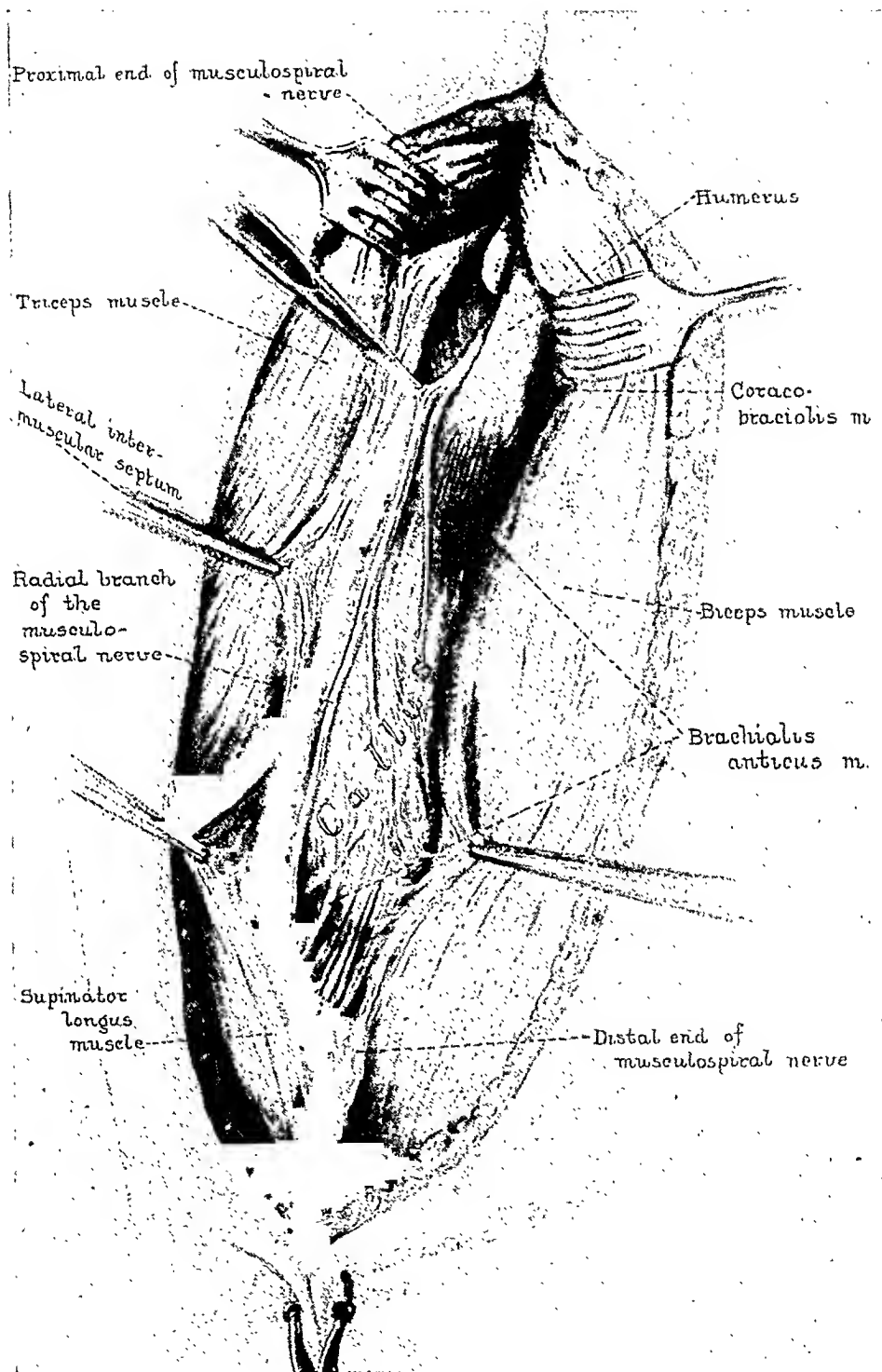


FIG. 2.—Anatomic relations of the proximal and distal neuromas of the musculospiral nerve, following complete severance at the time of fracture of the humerus.

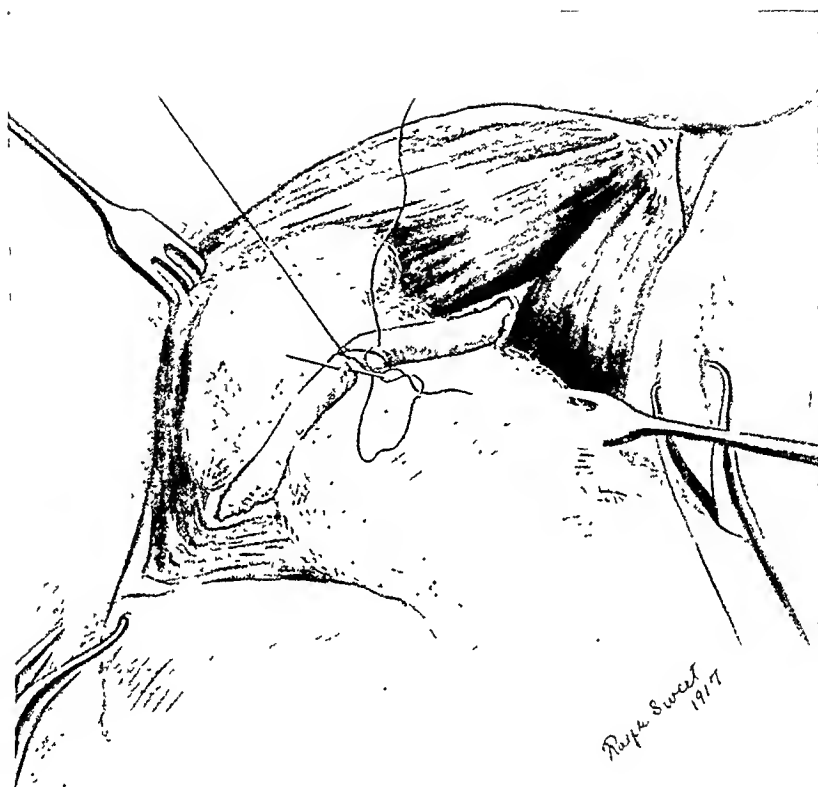


FIG. 3.—Anastomosis of the musculospiral nerve with silk. Stitches placed in the epineurium.

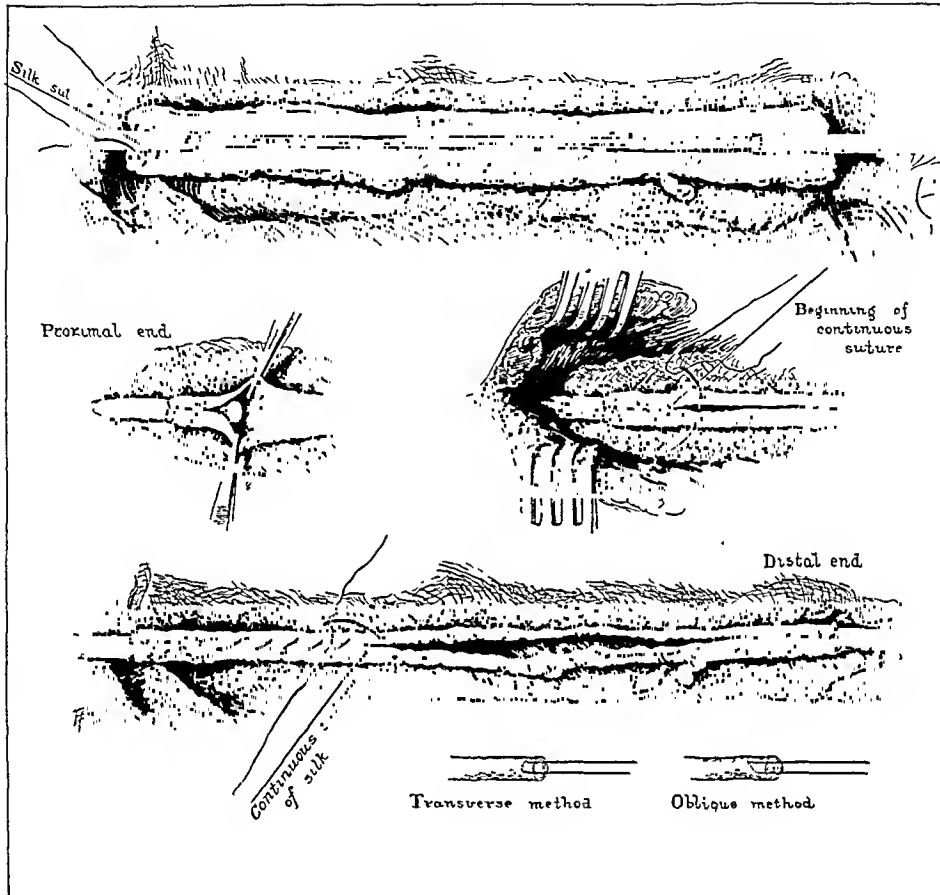


FIG. 4.—Method of anastomosis with silk and fascia. Various steps shown, in the covering of the cylinder of silk with fascia.

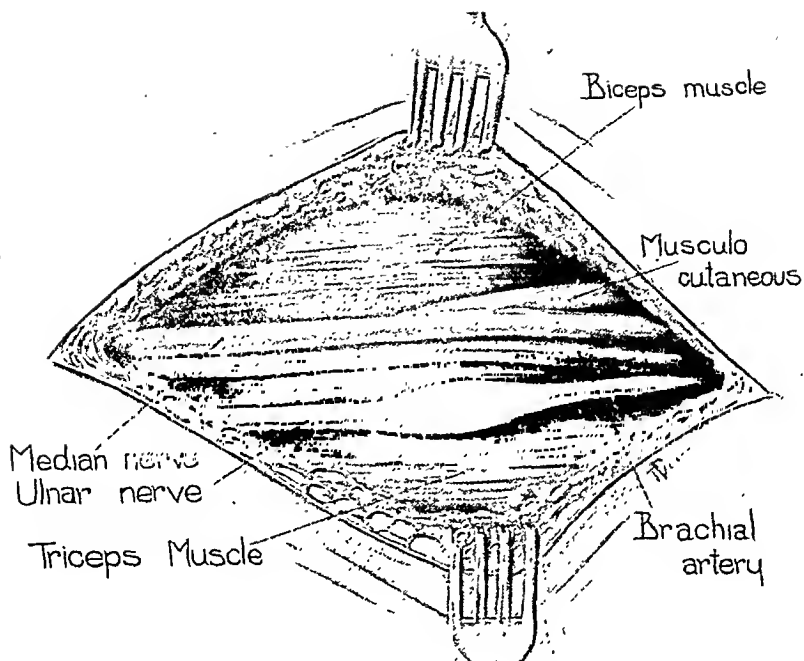


FIG. 5.—(202189) Exposure of the ulnar nerve in the right upper brachial region with a large neuroma due to trauma, without severance of the nerve.

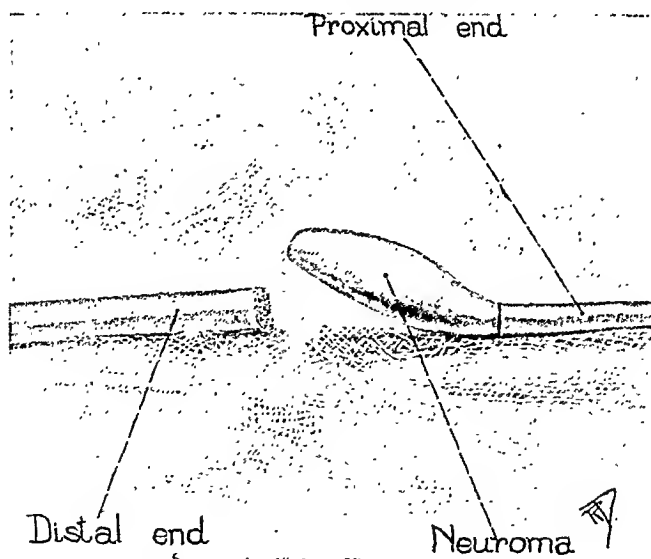


FIG. 6.—(202189) Resection of neuroma previous to anastomosis.

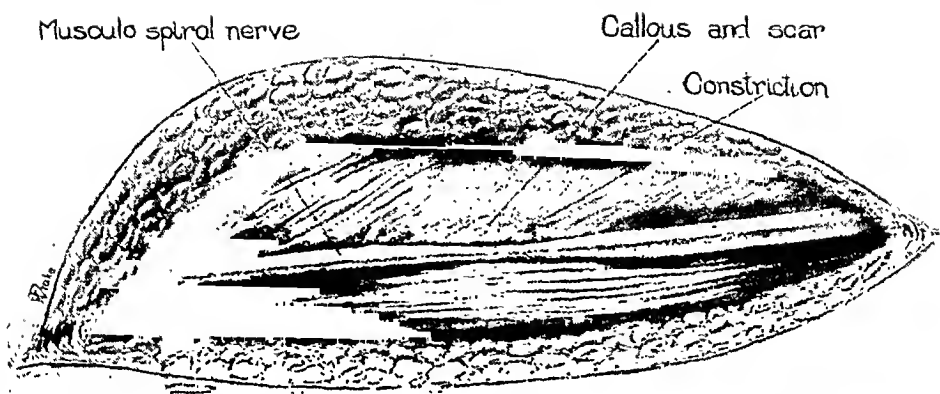


FIG. 7.—Exposure of the left musculospiral nerve, constricted by an exuberant callous and scar, without complete destruction.

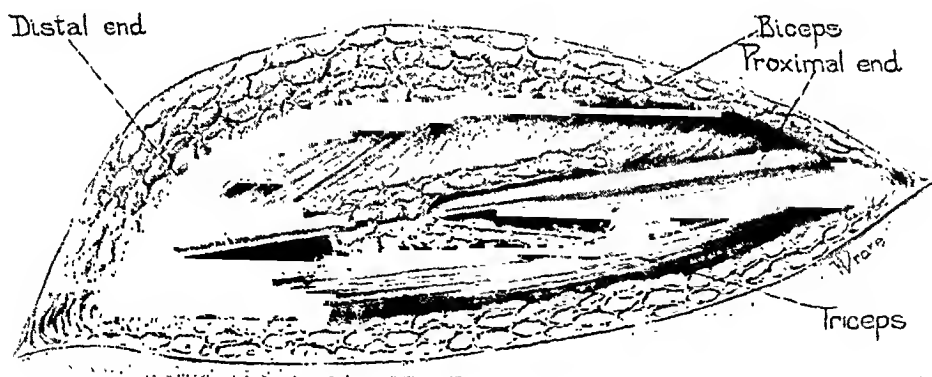


FIG. 8.—Covering the constricted musculospiral nerve with a facial flap to avoid further constriction.

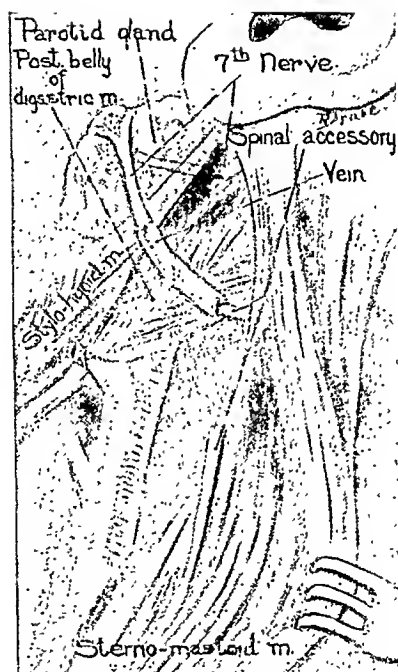


FIG. 9.—Anastomosis of the proximal end of the spinal accessory nerve to the distal end of the seventh nerve.

average time before maximum improvement was noted was twenty-seven months. The amount of improvement in the patients benefited was 72 per cent. of the sensory, motor, and trophic functions. Twenty per cent. only of these patients were improved, in 30 per cent. the results were indeterminate, and in 50 per cent. they were failures. In one patient the wound became infected. There were no deaths.

Four external popliteal anastomoses were made, all on males, whose average age was thirty years; all have been heard from following operation. The average duration of injury was twelve months, the shortest eleven months, and the longest sixteen months. Three of the injuries were associated with lacerated wounds, and one with dislocation of the fibula. Three of the operations were end-to-end anastomoses with silk and were covered with fascia, while the fourth was a plastic operation. The average time before improvement was noticed was eleven months; the average time before maximum improvement was reached was approximately twenty-four months. The average improvement obtained was 43 per cent. return of the sensory, 30 per cent. of the motor, and 80 per cent. of trophic function. In one case the result was a failure, and in another the result was indefinite. The failure of regeneration in one case was due to an infection in the wound.

Two sciatic nerves were repaired. One patient was injured eight years before coming to the clinic; the time the other was injured was not ascertained. The injury in one instance was due to a revolver bullet, in the other to a lacerated wound. Both operations were end-to-end anastomoses, one with silk and one with chromic catgut; fascia was used for covering in both cases. In the one case there was a gap of three-fourths of an inch between the nerve ends. The average time before improvement was noticed was six months; the average time until maximum improvement was reached was eighteen months. One of the two patients was heard from following operation; he reported 40 per cent. return of the sensory, motor, and trophic functions.

One right recurrent laryngeal was anastomosed end-to-end, one year after the injury. The patient was a male, aged thirty-nine years. The suture material used was not recorded. Improvement was first noticed twelve months after the operation; maximum improvement, 90 per cent. return of the motor function, was reached at the end of thirty-six months.

GENERAL SUMMARY OF CLINICAL FINDINGS

Of the forty-one patients operated on for nerve anastomosis, thirty-five were males and six were females. The average duration of injury was fifteen months. Seventy-three per cent. of the patients have been under observation or have been heard from since the operation. Seven of the forty-one injuries were associated with fractures; one with a dislocated bone, and thirty-three with lacerated wounds. Eighty and five-

tenths per cent. of the operations were end-to-end anastomoses; the balance (19.5 per cent.) were plastic operations of some sort. Sixty-five per cent. of the forty-one anastomoses were sutured with silk, 29 per cent. with chromic catgut. Fascia alone or with silk and chromic catgut in the form of a tube was used to protect the anastomosis in 49 per cent., vein was used in 10 per cent., and in 10 per cent. there was no covering. Seventy-three per cent. of the anastomoses were in direct apposition, 27 per cent. presented gaps varying from one-half to one and one-half inches in length, the average length being one inch. The average time before improvement was noticed was nine and nine-tenths months and the average time to reach maximum improvement was twenty-one and five-tenths months. The average amount of improvement obtained was 58 per cent. return of the sensory, 62 per cent. return of the motor, and 67 per cent. return of the trophic function. Seventy-three and one-tenth per cent. of all the patients operated on showed improvement, 17 per cent. of the operations were total failures, and 9.7 per cent. gave indefinite results. Four and eight-tenths per cent. of all the wounds became infected. There were no operative deaths.

OPERATIVE FINDINGS

Three clinical conditions may be found at operation:

1. Complete severance of the nerve with retraction, and a neuroma on each end. The neuroma on the proximal end is usually about twice the normal size of the nerve, while the neuroma on the distal end is very small, only about one and one-fifth times the size of the normal nerve. The portion of the nerve below the distal neuroma is enlarged to about one and one-sixth times the normal size of the nerve; it is œdematous and injected, and has a rather soft, mushy feel.

2. A diffuse and nodular thickening of the nerve, due to trauma. This occurs usually over some bony prominence; for example, a very common lesion is that found in the ulnar nerve, where it is situated over the inner condyle of the humerus, the anterior tibial, which passes around the head of the fibula. The proximal end of the nerve is normal in appearance and size, while the distal end is enlarged, œdematous and injected; the enlargement is about one and one-sixth times the size of a normal nerve. The nodular masses are pseudoneuromas and histologically show an interstitial neuritis.

3. A condition due to constriction of the nerve, the most common example being the musculospiral nerve, which is strangulated by the callus which forms after a fracture of the humerus. The histories in such cases are very significant in that the paralysis is progressive and comes on several weeks after the injury. The nerve proximal to the constriction is normal in appearance and size, while the portion distal to the constriction is frequently smaller than the normal nerve and not œdema-

tous nor injected unless the constriction is complete, when the appearance is the same as in the second group.

Paralysis of the seventh nerve may be caused by inflammatory processes or trauma; in either case surgery is indicated unless there is a spontaneous cure.

OPERATIVE TREATMENT

The ends of a severed nerve are retracted, generally, in the line of its original position. The ends are usually adherent to the mass of scar tissue, so it is quite important to expose normal nerve above and below the scar, after which the ends should be freed by very gentle dissection. After the neuromas have been exposed all of the neuromatous scar tissue should be removed. The bleeding is usually controlled by allowing the cut ends of the nerve to come in contact with dry sponges for from five to ten minutes. If this is not sufficient, the vessel may be tied with fine catgut.

In anastomosing nerves the sutures are applied to the sheath (epineurium) surrounding the nerve. They are inserted obliquely into the sheath, thus bridging the gap with a cylinder of silk, of five or six strands, to the nerve. If the ends can be brought into apposition, no fascial covering is necessary. If there is much tension, fine silk is preferable to chromic catgut for suture material. When it becomes necessary to leave a gap between the nerve ends it is important that this gap should be covered by membrane or fascia. An apposition is preferable to a gap, as the prognosis is much better. It should be remembered that a nerve will stand gentle stretching and that the extremities may be flexed to relieve tension.

The surgical procedure in a traumatized nerve with neuroma depends on the amount of existing paralysis. If the paralysis is less than 50 per cent., the epineurium and perineurium are divided to liberate the normal nerve fibres, but if the paralysis is more than 50 per cent. the neuroma is resected, exposing normal nerve fibres above and the definite nerve sheaths below; the ends are anastomosed in the same manner as when the nerve has been completely severed. This distinction is made on the grounds that if there is 50 per cent. function and further paralysis can be prevented, it is much better that the patient should be slightly handicapped than that the nerve should be resected and anastomosed with the chances of failure.

The surgical treatment of constricted nerves also depends on the amount of paralysis present. If the paralysis is less than 50 per cent., the nerve is freed from the surrounding scar tissue and protected by a cuff of fat and fascia. If the paralysis is more than 50 per cent., the constricted area is resected and anastomosed.

The surgical treatment of facial paralysis depends on the cause of the lesion, and it is better to wait a reasonable length of time after the injury (six months) before advising operative treatment, unless it can be deter-

GENERAL SUMMARY OF OPERATIVE RESULTS.
RESULTS OF IMPROVEMENT IN PER CENT.

Nerves operated on	Number of operations				Average duration of injury (months)	Cause of injury	Types of improvement, per cent.												Remarks								
	Average age	Males	Females	Married			Silk sutures	Chronic sutures	Facial covering	Vein covering	No covering	Freed from adhesions	Gap	Distance in inches	No gap	Time improvement began (months)	Time of maximum improvement (months)	Sensory		Motor	Trophic	Improved	Indeterminate	Failures	Patients not heard from	Wound infections	Mortality
Facial.....	24	4	5	4	5	26	2 following mastoid operation 7 following trauma 2 associated with fracture of the elbow 5 associated with lacerated wounds	6	0	0	4	2	1	0	0	9	8	19	71	89	0	0	29	0	0	0	Longest injury 15 years not heard from
Ulnar.....	20	6	1	7	0	6	4	4	1	3	0	0	0	2	1	10	16	63	63	71	0	0	29	0	0	0	
Radial.....	24	1	0	1	0	2	1 lacerated wound.....	0	0	0	0	1	0	?	...	11	21	72	72	72	...	100	0	0	0	2 cases reported (1 inch each)	
Median.....	23	7	0	6	1	18	7 lacerated wounds.....	3	3	5	2	1	0	2	1	11	11	72	72	72	0	14	14	0	0	Longest gap 1½ inches not heard from	
Musculospiral	36	10	0	3	7	28	9 associated with fracture of the humerus	7	7	7	...	2	1	4	1½	12	27	72	72	20	30	50	10	0	0	Longest gap became infected	
External popliteal.	30	4	0	2	2	12	1 lacerated wound of the fibula	3	0	3	...	1	0	2	(1)	11	24	43	30	80	50	25	0	25	0	Longest gap became infected	
Sciatic.....	22	2	0	2	0	(1) 96	3 lacerated wounds..... 2 lacerated wounds.....	1	1	2	...	0	1	(1) 24	(2) 34	6	182	40	40	40	50	0	50	0	0	Case 8 years' duration partly improved	
Right recurrent laryngeal.....	39	1	0	1	(1) 12	12	1 following thyroidectomy..	1	0	0	0	0	0	0	0	1	12	36	90	100	0	0	0	0	0		
Totals.....	41	35	6	25	16	...	...	27	12	20	4	4	7	11	...	...	...	...	...	...	...	...	...	...	...
Averages.....	28	...	...	...	15	...	...	...	...	...	...	...	...	...	...	10	22	...	...	...	...	...	...	...	...
Per cent.....	...	...	...	...	...	...	65	29	49	10	10	20	5	...	...	...	58	62	67	73	10	17	27	5	0	Note.—Improvement based on 41 cases

NOTE.—19.5 per cent. had plastic flap operations. 27 per cent. had interneral gaps. 10 per cent. were indeterminate. 80.5 per cent. had end-to-end anastomosis. 73 per cent. had no gap or were not reported. 17 per cent. were failures. 73 per cent. were improved. 62 per cent. average degree of improvement.

mined that the nerve is completely severed, in which case operation should be undertaken as soon as the latent infection has cleared up. If at the end of six months there is no sign of regeneration, one of two courses may be followed: Anastomosing the distal end of the seventh nerve to the hypoglossal, or anastomosing it to the spinal accessory, preferably the latter.

SUMMARY

1. The regeneration of the peripheral nerves may be accomplished by nerve anastomoses.

2. The degree of regeneration depends on (a) duration of time between injury and repair, the shorter the period the greater the regeneration. The possibility of regeneration is very slight after three or four years, (b) actual loss of nerve tissue, and (c) retraction of severed ends.

3. In the technic of nerve repair (a) no covering is necessary if the freshened ends can be sutured in close apposition; (b) if an intervening gap remains it should be tubulized, preferably by fascia; (c) if the gap is longer than 5 cm. tendon transplantation and arthrodesis should be considered instead of nerve anastomosis; (d) autogenous transplants may be considered for short gaps, but they are of no greater value than tubulization; (e) in all technic, the wound should be free from hemorrhage and infection and the nerve ends should not be traumatized; and (f) during the post-operative convalescence, the paralyzed muscles should be massaged and passive motion should be administered.

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RHINOPHYMA *

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THIS distressing disfigurement occurs in the third or hypertrophic stage of acne rosacea. Fortunately, in spite of the frequency of acne rosacea, this condition is not an inevitable or even common termination of the disease.

It is inseparately associated, especially in the layman's mind, with inordinate indulgence in alcoholic beverages, but it has occurred in the case of many very temperate persons and has been often seen in total abstainers: consequently, we may hardly expect it to disappear with the enforcement of the recent amendment to our Federal Constitution. Excessive use of tea, coffee, tobacco and good food, as well as extreme cold and heat, are considered by the dermatologists as causative factors. There is probably no comfortable indiscretion which has not been named in this connection, so there is nothing more to add in the way of causes, but as far as the three cases here reported are concerned, I think they may be acquitted of any charge of over-indulgence in the flesh pots. A fact probably worthy of note is that rhinophyma is very rare in women and yet they are notoriously indiscreet in their treatment of the alimentary tract, both as to what they put in it and the regularity with which they evacuate it.

Looked at pathologically this condition can be expressed in one word—hypertrophy—involving particularly the connective tissue, the sebaceous glands and the blood-vessels of the skin. The most striking of the hypertrophic features is the great size of the sebaceous glands, their big blocked ducts and their apparent increase in number. The big tortuous capillaries and veins are conspicuous superficially but they are not found to the same extent in the deeper portions of the skin. The thickness of the skin even in the absence of lobulation is surprising. The usual limitation of the hypertrophy to the lower half of the nose is difficult to explain but renders its surgical treatment much easier. Where pendulous lobules of hypertrophied skin hang from the alæ, the skin at their bases is never so thick as in other parts of the involved area. This renders simple excision followed by suture possible in many cases. There seems to be no limit to the growth of the lobulated masses. In Keen's case, the only one I believe reported before this Academy (January 4, 1904, *ANNALS OF SURGERY*, vol. xxxix, page 665), the patient was obliged to lift his enlarged nose up out of the way in order to take soup from a spoon or

* Read before the Philadelphia Academy of Surgery, March 13, 1919.

liquid from a glass. If the commonly assigned cause of this condition is the true one, it is unfortunate that the patients are not so handicapped in the early stages of the disease.

Electrolysis and galvano-cautery puncture probably constitute the only methods of treatment of this disfiguring condition which may be said to be generally practised, and yet I am inclined to believe excision under a general anæsthetic gives better, quicker, more certain and more lasting results.

I assisted Doctor Keen in 1903, when he operated upon the case already referred to, in which the result was most gratifying, and since have operated on three cases. Unfortunately I have failed to locate two of these patients recently, but the results engendered great gratitude in the patients, and I believe if any marked recurrence had taken place they would have returned. The photographs before and after in two of the cases show what was accomplished. No photograph was made in the second case, but the condition in this case was quite as marked as in the others, interfering, as the patient assured me, with his "business" (that of a pedlar), and the result equally good.

The surgical procedure is quite simple and consists of excision of the lobules and the paring or shaving of the hypertrophied skin until the nose has assumed the size and shape which might be considered normal. The work might be considered more suited to a sculptor than to a surgeon.

Although bleeding is very profuse from innumerable vessels, it is very rare that any of these require a ligature: even the use of forceps is rarely required excepting in the case of the vessel at the base of the ala. One should be careful not to pare away the entire thickness of the skin because if this is done it delays healing and necessitates the formation of cicatricial tissue. In Case I it will be noticed that there are two such areas on the left ala.

The way in which the sebaceous material exudes from the divided sebaceous ducts and skin is quite like that of butter or cheese squeezed through a piece of cheese-cloth. One can readily believe that there is not only a hypertrophy of the sebaceous glands but an increase in their number. When the nose by the process of shaving has been brought to what may be considered normal, the bleeding can be arrested to some extent by hot applications and pressure, but oozing will continue for a number of hours. I have allowed several layers of gauze to remain in contact with the denuded area for a number of days and have simply changed the outer layers of gauze. If the entire thickness of the skin has not been removed, it is remarkable how quickly healing takes place in these cases.

The surgical procedure and the results are so satisfactory that I am convinced that many more of these cases should be operated upon.



FIG. 1.—Case I before operation.

Cancer
14 Day after operation



FIG. 2.—Case I, fourteen days after operation.



FIG. 3.—Case III, before operation.



FIG 4 —Case III, twenty-eight days after operation.

CASE I.—T. H., aged fifty-seven years, operated upon at the Jefferson Hospital, February 2, 1907. Fig. 1 shows the appearance of the nose before operation and Fig. 2 the condition fourteen days later. In this case there were four small points, two on each ala, where the entire thickness of the skin was removed and here epithelialization was delayed about a week.

CASE II.—A. M., aged fifty-five years, operated upon at the Pennsylvania Hospital, October 22, 1913. In addition to the involvement of the nose in this case there were numerous small sessile masses of hypertrophied skin on the cheeks. Some years previous the patient had a large pedunculated mass removed from the right side of the nose. Because of an old chronic inflammatory condition of the lungs, this patient was operated upon under chloride of ethyl anaesthesia. In this case I avoided penetration of the skin and the promptness with which healing took place was very surprising.

CASE III.—J. A., aged sixty-three years, operated upon at the Jefferson Hospital, June 20, 1916. In this case the involvement of the skin extended over nearly the entire nose. The second photograph was taken a month after the operation. This patient was seen within a few weeks of this printing, and he had had no recurrence of his trouble after three years.

TRANSTHORACIC LAPAROTOMY*

By WILLY MEYER, M.D.

OF NEW YORK

ATTENDING SURGEON TO THE LENOX HILL AND POST-GRADUATE HOSPITALS

ACCESS to the organs within the abdominal cavity has been gained from every conceivable direction, according to the purpose of the operation and location of the field to be attacked.

Besides the great variety of incisions in front and over the sides of the abdomen—perpendicular, transverse, curved, angular, flap—we have learned to reach appendix and gall-bladder, cæcum and colon simultaneously with operations on the kidney; uterus and appendages through the vagina; rectum and sigmoid from the sacro-coccygeal region. The favored route for the opening of a subphrenic abscess has been through the complementary pleural space, with the help of rib resection and incision through the diaphragm.

In cases of injury to organs in the vault of the diaphragm—convexity of liver, upper pole of spleen, cardiac portion of the stomach—the injury occurring by way of the chest, it has been found best to have the incision follow the course of the injury; that is to say, after performing thoracotomy and attending to the injuries inflicted on the intrathoracic organs, the surgeon deliberately incises the diaphragm or enlarges the visible wound in the same and deals with the abdominal organs as the case may demand, (transthoracic—also transpleural or transdiaphragmatic—laparotomy).

Ferdinand Sauerbruch was the first to proceed systematically along these lines. Standing on the firm ground of the employment of a differential pressure apparatus, he carried thoracotomy to its logical conclusion in these cases. He reports three emergency operations of this kind:¹

CASE I.—Compression of thorax; no external lesion. Increasing serious symptoms demand operation. Intercostal incision (7th), under differential pressure, shows rupture of lower lobe of left lung. Incision through diaphragm. Large effusion of blood; pedicle of spleen torn; splenic vein bleeding. Extirpation of spleen. Suture of diaphragm and lung; closure of chest. Recovery.

CASE II.—Young man with shot wound of thorax, right side near middle line, at level of costal arch, demanding prompt intervention. Intercostal incision (6th). Wound found in middle and lower lobe of lung, also of pericardiophrenic artery and in diaphragm. Suture of lung wound; ligature of bleeding vessel. Division of diaphragm. Liver torn at convexity. Tampon left in latter and conducted outward through abdominal stab. Suture of diaphragm and thoracic wound. Recovery.

CASE III.—Shot wound in left seventh intercostal space. Abdominal muscle spasm gave indication for thoracotomy, in the course of which the diaphragm had to be split and the injured organs within the thoracic and abdominal cavity were attended to. Recovery.

Sauerbruch lays stress upon the necessity of dividing the diaphragm in a direction transversely, or at least obliquely, to the direction of its

* Read before the American Surgical Association, June 16, 1919.

¹ Trans. of German Congress of Surgeons, 1912, i, p. 142.



FIG. 1.—Shows entrance of bullet in arm and chest (sixth intercostal space). Insert at upper left-hand corner: The bullet which was extracted from the liver; actual size.



FIG. 2 —Radiograph, showing bullet in lower portion of right chest

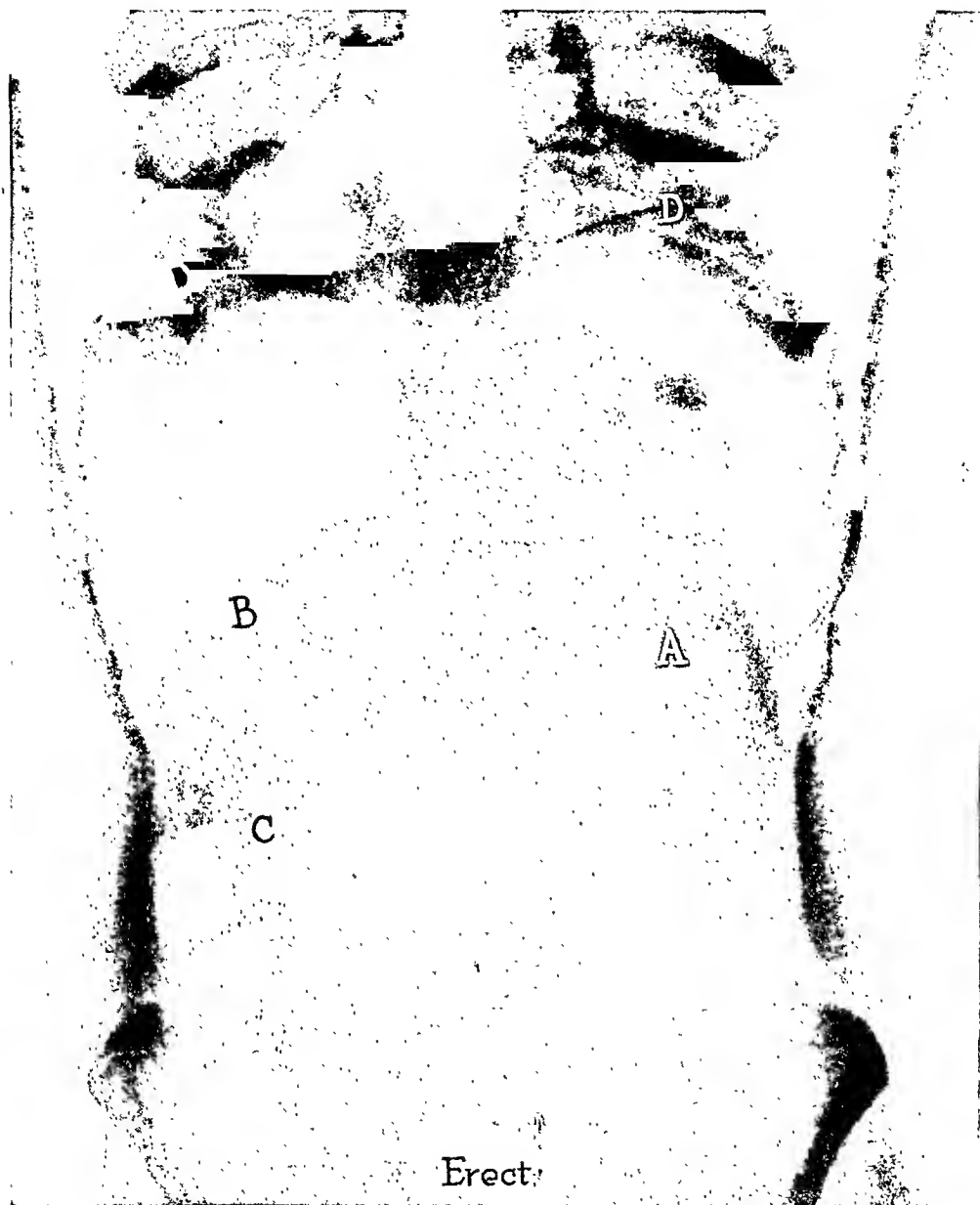


FIG. 3.—Shows the immediate effect of insufflation of oxygen into the peritoneal cavity. Note the pronounced dropping away of liver and spleen from the diaphragm. (Reproduced here by courtesy of Dr. W. H. Stewart, of New York. See ANNALS OF SURGERY, July, 1919, page 96).



FIG 4 —Illustrates air-tight thoracic drainage, as carried out in every case of thoracic operation under the author's care at the Lenox Hill Hospital, New York. For immediate and unobstructed inspection the drainage bottle is placed under the lower end of the bed. Patient rests on his back with right shoulder and hip supported on small pillows.

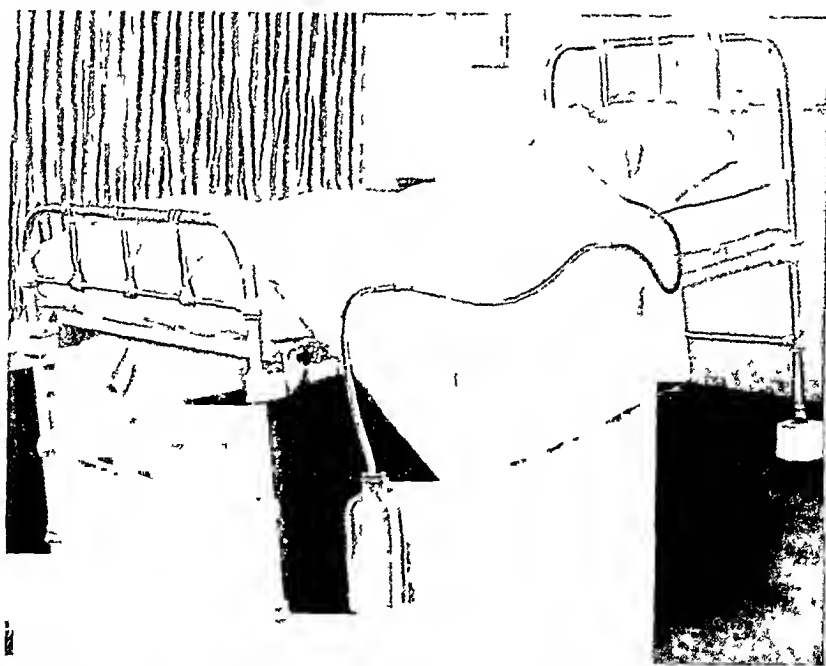


FIG 5 —When tired of one position during the time of drainage patient can also turn on his right side, with the drainage of the right chest not interfered with (right latero abdominal posture).



FIG. 6.—Intercostal incision healed.

muscular fibres—not *parallel* with the same—in order to avoid injury to the phrenic nerve, which would paralyze the diaphragm on that side.

A further case belonging to this group was reported by Kenneth Bulkley before the Surgical Section of the N. Y. Academy of Medicine, in November, 1916.²

Stab Wound of the Chest and Diaphragm; Thoracotomy; Laparotomy; Packing of Punctured Spleen, Recovery.—Boy, fourteen years, stabbed in left lower chest with a knife, one-half hour before admission. Through the wound, one-half inch in length, protruded a bit of omentum. Resection of ninth rib. It is seen that the knife had penetrated the pleural cavity without injury to the lung, and had inflicted a wound in the diaphragm through which the omentum prolapsed. The omentum was amputated, the stump reduced and the rent in the diaphragm closed. Pleural drainage. Twelve hours later signs of peritoneal irritation and intra-abdominal hemorrhage. On incising the abdomen it was found that on the diaphragmatic surface of the spleen was a punctured wound, nearly an inch long, still actively bleeding; packing with gauze. The drainage tube in the chest was removed after thirty-six hours, the abdominal packing after forty-eight hours, and both wounds healed practically per primam. Patient was presented in good condition one week after the injury.

In January of this year, I had occasion to do a transthoracic laparotomy on a patient who had been wounded about six weeks before his admission to the hospital with the chest wound firmly healed. As the case presents a few features of interest, I shall report it in full:

J. G., an Italian, thirty-one years of age, was accidentally shot on November 29, 1918, with a 32-calibre pistol. The bullet entered just above the external condyle of the right humerus and passed through the tissues of the arm, without injury to the bone, blood-vessels, or important nerves, although the point of exit corresponded to the inner (bicipital) sulcus. It then entered the thorax in the sixth intercostal space, in the anterior axillary line, fracturing the seventh rib (Fig. 1). There was no exit of the bullet. The man was admitted to one of our city hospitals and recovered without operation and without serious symptoms. He claims to have coughed some blood during the first days, but definite information regarding this point could not be obtained.

Not long after his discharge from the hospital, he consulted Doctor Carlo Savini, of New York, who had a stereoscopic X-ray picture made. This showed the bullet seemingly in the lowest portion of the right side of the chest, most likely within the lung (Fig. 2). Doctor Savini very kindly referred the patient to me for an opinion regarding indication for removal of the bullet by operation. The man seemed to be in excellent condition and had no special complaints, excepting now and then drawing sensations in the region of the injury.

According to formerly entertained views, expectant treatment was here in order. If no untoward symptoms developed, the patient might carry the bullet for life. Some of our best surgeons with

² Report of meeting of November 3, 1916, New York Med. Record, January 27, 1917.

wide experience still adhere to this view at the present time. In rendering my opinion I tried to consider the patient's future. It seemed to me, if the bullet was in the lung, the case might well be placed on a level with an interval appendix operation, demanding a prophylactic interference in order to avoid more serious consequences. I considered that an exploratory thoracotomy done at this time—with the bullet within the lung tissue—might afford a chance of finding and removing it. Such an operation certainly involved less risk to the patient than a possible future suppuration within the lung; and should the bullet be found within or below the diaphragm, conditions encountered during the operation would have to be the guide as to further procedure. Besides, I remembered that excellent remark of Sir Berkeley Moynihan's: A bullet in the body is two bullets, *i.e.*, one in the respective organ, the other in the patient's mind. I advised operation and, with Doctor Savini's consent, had the patient admitted to the Lenox Hill Hospital. Before proceeding, another stereoscopic radiograph was taken, and the patient repeatedly examined fluoroscopically by Dr. W. H. Stewart, the radiographist of the Lenox Hill Hospital; but the bullet could not be definitely located. The report reads:

"Fluoroscopic, combined with serial röntgenographic examination of the right chest reveals a bullet located between the tenth and eleventh ribs. Under the fluoroscope we noted that the bullet would rise and fall with the diaphragmatic movement. I am suspicious, therefore, that it is lodged within this muscle, or in close relation to same. It lies well posteriorly."

No matter whether in this case the bullet was situated within the lowest portion of the inferior lobe of the right lung, or within the diaphragm, or below the same in the liver, it was evident that it could be reached with safety only by way of the chest, not by way of the abdomen.

Operation (January 8, 1919).—Intratracheal insufflation (Doctor Muehleck). Incision in right eighth intercostal. Contrary to expectations, an absolutely free pleural cavity was entered; only the inner aspect of the lower lobe of the lung was firmly adherent to the diaphragm. In view of the experience had by our colleagues in the war, I had first intended not to prepare for the emergency use of differential pressure, but to make a simple intercostal incision, expecting to find far-reaching adhesions. Now I felt happy that I had prepared for and was ready to meet the emergency. There is no doubt that without a differential pressure method already in action, the patient would have suffered an acute operative pneumothorax with its possible consequences, until positive or negative differential pressure could have been applied to relieve the situation. The thorax, having been incised with the apparatus in action, no annoying symptoms occurred.

The lung was allowed to collapse somewhat. Careful palpation of the lower lobe failed to find the bullet. A small, round scar in the diaphragm seemed to point to its penetration by the bullet. Turning

the palm of the hand and going carefully over the lower diaphragmatic vault, the bullet was palpated posteriorly to the central convexity of the diaphragm, quite a distance from the sternal aspect, and to the left of the median line.

The question now was: Should I continue the operation and remove the bullet?

On the day preceding the operation I had met one of my colleagues at the hospital who has seen considerable active war service. We discussed the case. He condemned operation. "One ounce—more or less—of lead in the body would make little difference," he said, "whereas the operation, as planned, might prove serious, if not disastrous to the man." My conscience then began to plague me. I did not want to do an operation without definite indication, but I also thought of the two points mentioned above, particularly Moynihan's words, and therefore concluded to adhere to my decision to do an exploratory thoracotomy and, if necessary, pneumotomy. Now, suddenly faced with the fact that the bullet was not in the thorax at all, but was probably embedded in the liver, I found it difficult to decide whether to go ahead, or let the patient take the chance of having a liver or subphrenic abscess develop later on—the worst that possibly could happen.

Next to me, watching the operation, stood my old friend, Doctor De Vecchi, of New York, for whose good judgment I always have had the highest regard. I asked him for his opinion and he said: "Doctor, you have done a big exploratory operation; you are down upon the bullet; go ahead." And then he repeated Moynihan's words which we had discussed before beginning the operation. Although I hesitated for a moment as to whether I would be doing the best for the patient, I saw the correctness of Doctor De Vecchi's opinion and started to divide the diaphragmatic vault six to seven inches below the level of the chest wall. This proved no easy matter, partially on account of the depth, partially on account of the continuous motion of the field of operation. To steady it with stick-sponges seemed impossible. With a straight, long bistoury the abdominal cavity was entered by an incision about $2\frac{1}{2}$ inches long. Quite some arterial hemorrhage from the diaphragm was encountered, but a clamp placed on either side of the phrenic wound nicely controlled it. The subdiaphragmatic space was then entered. It was perfectly free. There were no adhesions of any kind. The bullet was palpated within the liver. Again a somewhat difficult and rather delicate step in the operation followed, *viz.*, to pass the cautery through the opening in the diaphragm so far down, avoid cauterization of the diaphragmatic wound, and then correctly incise the liver which naturally shared the diaphragmatic unrest. I did not dare enter the liver with a knife, for I had no technical chance of properly dealing with a hemorrhage. So I drew a line with the cautery through the liver substance, where I felt the bullet, and repeated this a second and third time, when suddenly pus was struck. A small quantity partially oozed out and

partially was pressed out and caught on wipes; a culture was taken. The bullet was found and removed from the liver. It was a short 32-calibre missile (Fig. 1).

The unexpected presence of pus changed the situation and the plan of the operation. The liver wound bled slightly and was difficult of access; blood had run down into the subdiaphragmatic space, and now, in addition, pus had been encountered. Tamponade was required. Should I treat the abdominal and the thoracic cavities separately and conduct a gauze strip, placed into the liver wound, and a second one, introduced into the subphrenic space below the liver incision, out through a special stab in the abdominal wall, and then close the wound in the diaphragm and drain the supposedly infected pleural cavity? It certainly seemed the most surgical procedure. However, I considered the whole field of operation infected, the subdiaphragmatic space, as well as the wound in the liver, the wound in the diaphragm, and the pleural cavity, and, therefore, a straight drainage by means of the tampons through the diaphragm and thoracic cavity appeared more advisable, whether rightly or wrongly, I would not venture to decide; but I feared a further contamination of hitherto unhandled intra-abdominal regions. Besides, it is customary to drain the posterior aspect of the liver and subphrenic space through the lower portion of the thorax, though this is usually done after stitching the borders of the diaphragm to pleura and posterior periosteal sheath of the resected rib, thus shutting off the pleural cavity above. The wound in the diaphragm was therefore closed up to the tampons by interrupted sutures, and Kenyon's drain placed in the posterior angle of the thoracic wound. The latter was closed as usual, in layers, tightly, with pericostal chromic gut retention sutures and a continuous suture for the various muscles and the skin. The gauze drains were cut short in front of the chest, and the perforated cork, surrounding the Kenyon drain, pressed upon the same as a buffer after a small piece of split gauze had been pushed underneath the safety pins, securing their ends. The skin surrounding the drainage region was then heavily covered with sterilized zinc ointment and a large, partially split piece of rubber dam put on top of it all, thoroughly surrounding the Kenyon drainage tube and covering the round cork-plate, through which it passes. The rubber dam was intended to act as a valve, should the gauze drains permit air to pass. The dressing was completed with dry gauze, held in place by 2-inch strips of zinc adhesive plaster, and a temporary Desault bandage, to fixate the right arm for the first twenty-four hours. The patient reached his bed in good condition. As a prophylactic measure the heart was stimulated with hypodermic injections of sodium benzoate of caffeine and camphorated oil and the phrenic irritation quieted with morphine and atropine. The head-end of the bed was raised on blocks.

Sero-sanguinolent drainage in the first twenty-four hours, 250 c.c.; in the second, 35 c.c.; in the third, 30 c.c. (Figs. 4 and 5). Heart

action soon became normal, but temperature fluctuated. First change of dressing on the sixth day after operation. There being no certainty that adhesions had formed to keep the lung distended throughout, the precaution was taken to change the dressing with the help of the positive cabinet. The two gauze drains in the liver substance and subphrenic space were removed without difficulty, giving exit to a small amount of sero-sanguinolent fluid; Kenyon's drain was left *in situ* undisturbed and the dressing secured and covered as at first. Some retention of sero-sanguinolent fluid was found in the skin wound and drained. The temperature in the evening of the same day was 103.2° ; pulse strong and quiet; general condition good. Kenyon's drain was removed and exchanged for a small sized rubber tube two days later. After repeated dressings the tube could soon be removed. The patient made an uneventful recovery (Fig. 6).

The foregoing rather extensive description of the operative experience has seemed permissible, in view of the pus, so unexpectedly encountered in the liver, evidently representing a beginning hepatic abscess. It at once changed the entire aspect of the operation as well as of the after-treatment. Although the serological examination of the culture taken proved the pus to be sterile, the only advisable procedure at the time of the operation, in view of the unknown character of the pus, was: *drainage*.

The previous transthoracic laparotomies for liver or spleen injury in the vault of the diaphragm had been made soon after the accident, and before suppuration could have set in.

The diaphragm has also frequently been split in the course of thoracotomies, which were done in cases of oesophageal and cardiac carcinoma in order to reach and deal with the diseased portion of the stomach. But there again, the rent could be sutured immediately afterward, closing the abdominal cavity, and drainage was not indicated.

No doubt, during the war, surgeons have often been called upon to enter the abdomen through a chest wound, the course of the injury demanding or inviting such an advance. It is to be hoped that they will publish their experiences. Conditions found in such cases are somewhat different from those in the case related here, inasmuch as in the war injuries the chest had been open for some time, and the question of avoiding the deleterious effects of the operative and post-operative acute pneumothorax did not have to enter the surgeon's deliberations.

After the operation, related above, the question came up whether the seat of the bullet in lung, diaphragm, or liver could have been properly diagnosed before operation.

According to a communication made by Doctor Stewart before the American Association for Thoracic Surgery at its Second Annual Meeting at Atlantic City, June the 9th this year, a differential diagnosis as to the location of this bullet might have been possible röntgenographically,

after establishment of an artificial pneumothorax and insufflation of oxygen into the abdominal cavity. Doctor Stewart has taken up the latter procedure on a larger scale, as the first in America, in conjunction with Dr. Arthur Stein, of New York City, Associate Gynecologist to the Lenox Hill and Harlem Hospitals, the method having been proposed and tried by Lorey, of Hamburg, and Weber, of Kiew, seven (respectively six) years ago, and having been discussed in literature repeatedly in the course of the last years.³ Doctor Stewart's radiographs, showing the effect of oxygen insufflation into the peritoneal cavity with reference to bringing out details, are beautiful and convincing (Fig. 3). His article was published in the July, 1919, issue of the ANNALS OF SURGERY.

The conclusions that could be drawn from this case and the other transthoracic laparotomies on record are the following:

1. Recent wounds which have entered the abdomen through the chest and have likely seriously injured one or more of the principal organs situated within the vault of the diaphragm are best promptly explored with the help of a transthoracic laparotomy.

2. Injuries to the convexity of the liver or upper pole of the spleen, without previous penetration of the chest, if not satisfactorily accessible from below, can be thoroughly attended to by the surgeon if he follows the transthoracic route.

3. The experience gained in general in the last war would seem to hold good also for bullet wounds of the convexity of the liver inflicted in times of peace, *viz.*, to remove the missile and therewith eventually avoid more serious consequences to the patient later on.

4. Whether the operation should be done immediately after the accident or later depends upon the seriousness of the concomitant symptoms of the patient. If a prompt, transdiaphragmatic attack is not made imperative by increasing symptoms of pressure-pneumothorax or severe internal hemorrhage, a secondary operation may be best for the patient.

5. These operations are best done with the help of some differential pressure apparatus.

6. In case of the necessity arising to leave tampons in the abdomen, it appears best, from a surgical standpoint, to deliver them through a special abdominal stab. The diaphragmatic wound can then be sutured, and thus the physiologic separation of thoracic and abdominal cavities be reestablished.

7. Temporary air-tight drainage of the chest appears here, too, to be the safest procedure for after-treatment.

8. The establishment of an artificial pneumothorax and oxygen insufflation into the abdominal cavity bid fair to make the röntgenologist definitely localize the seat of the bullet if it be found near the diaphragm.

³ See, E. Weber: Fortschritte auf dem Gebiete der Roentgen-strahlen. Vol. xx, 5, 1913, and O. Goetze, Muench. Med. Wochenschr., November 12, 1918.

DIAPHRAGMATIC HERNIA

By JOSEPH L. DECOURCY, M.D.

OF CINCINNATI, OHIO

FROM recent literature on the subject it appears that diaphragmatic herniæ, of the non-traumatic type are more frequent than ordinary supposed. Two of the early cases reported were those of Cranwell (*Rev. de Chir.*, January, 1908) and N. B. Carson (*Interstate Med. Journal*, April, 1912) operated successfully through the transthoracic route. Recently Angelo L. Soresi (*ANNALS OF SURGERY*, March, 1919) reported a case operated successfully through the peritoneal cavity. Other cases have been reported and various modes of treatment described.

The following case presented itself to our clinic in the latter part of April, 1919. The symptoms recorded resembled very closely those presented by Case I of Dr. Angelo L. Soresi and therefore I will outline his case first in order to show the resemblance.

CASE I (Soresi).—"Miss M. E., aged nineteen, girl poorly developed and rather anæmic. Her history is one of long suffering, dysmenorrhœa, constipation, indigestion, and severe pain in the abdomen, the nature of which the girl cannot explain better than by saying that she suffers every time she has her menses, that she had once a very severe pain in the right side of her lower abdomen, that she had for a long time a dull pain over there, that she suffers from indigestion and constipation, that at times she cannot breathe, that she feels like crying all the time; in fact, she is a rather neurotic subject, discouraged and very melancholic. When seen by the writer she complained especially of pain in the lower abdomen and pain all over her chest and stomach."

As I have already stated the symptomatology of my own case closely resembled the above.

CASE II.—Miss I. V., aged twenty-five, girl poorly developed and rather anæmic, began to menstruate when seventeen years of age. She has suffered since beginning menstruation with dysmenorrhœa, constipation and indigestion. Before this time she could not be positive whether or not the constipation and indigestion existed. In the past few years the symptoms have become progressively worse and she now has severe epigastric pains, whereas previously only a sense of fullness and indigestion existed. The pain at present seems to come on immediately after eating and I have placed great importance upon this point in the symptomatology. Vomiting occurs without premonition and seems to gush from the patient. She complains of smothering and shortness of breath at times. Physical examination revealed the heart pushed one and one-half inches to the right of the sternal margin and hyper-resonance over the area previously occupied by the heart.

The X-ray report of Dr. Wm. M. Doughty was recorded as follows :

Fluoroscopically and with stereoscopic plates of the chest we discovered an area which varied in size at different times from that of a small orange to an area twice that size, which began in the middle line and extended from two to four inches from the diaphragmatic attachment on the left side, upward, then obliquely extending from this upper portion outward and downward and to the right, joining the diaphragm two inches from the median line to the extreme lower part of the right chest. This was easily demonstrated as containing air in the upper portion and fluid in the lower portion by movement and by palpation which gave us a fluid wave over the upper edge of the opaque shadow. At all times the heart shadow was shown slightly more to the right than normally.

The opaque meal given by mouth was seen to enter normally through the œsophagus, through the cardiac end of the stomach, the greater curvature of the stomach being distinctly seen and that part of the stomach shown being higher up in the abdomen and higher up to the left. The normal amount of barium used for stomach examination readily filled that part of the stomach in the abdominal cavity and was easily expressed into this previously described area, above the right diaphragm, through a narrow opening to the right of the œsophagus. At no time was I able to see the pylorus or any of the opaque meal leaving the stomach and entering the small bowel while the stomach remained in this position.

Allowing the patient to stand for half an hour without any manipulation or sensation upon any part of the body, the examination then made disclosed the stomach to be entirely within the abdominal cavity, being quite long, the entire fundus being within the pelvis, and by palpation under the fluoroscope it was easy to entirely fill the pylorus and rather duodenal cap which at all times was placed higher in the abdomen and expressed this meal from the duodenal cap into the normal second portion of the duodenum.

All of this following the elapse of half an hour was shown to be in the abdominal cavity.

The twenty-four-hour examination showed the entire colon to be in normal position in the abdomen, very freely movable and with normal progress to the opaque meal.

There was one small opaque shadow of barium, freely movable, which was shown to be between two and three inches above the central part of the transverse colon and very slightly to the right of the median line which I could not demonstrate to be either in the stomach or in the colon. I would consider this as probably being a slight diverticulum filled with the opaque meal and its attachment I could not discover.

The operative findings were as follows: A long, high right rectus incision was made about one-half inch to the right of the median line. The abdominal walls were retracted and lifted so as to expose the entire abdominal cavity. With this exposure neither the stomach nor the transverse colon could be seen. A small portion of the omentum protruded from beneath the left lobe of the liver. By making traction upon the omentum the transverse colon and stomach were returned with some difficulty into the abdominal cavity. During this manipulation the sound of air could be heard passing into the tissues about the stomach.

After the stomach was returned to the abdomen the tear in the diaphragm could not be seen, but the tissues about the gastro-hepatic omentum would rise with each inspiration, giving the impression of air

beneath. When these tissues were opened, it could be seen that we were dealing with a distinct sac entering the pleural cavity and closely adherent to surrounding structures. To perform a classical operation upon the diaphragm in this case was entirely out of the question because of the dangers which would be incurred when working about such a complicated area, so that we had to be satisfied with passing a silk purse-string suture about the sac at the diaphragmatic opening. The opening in this case was to the right of the œsophagus about one and one-half inches in diameter and it appeared that the lesser curvature of the stomach entered the opening first and dragged the transverse colon after.

Immediately after closure of the sac the suction ceased.

Symptomatology.—In studying the foregoing cases and other cases which have been reported in the literature, I will try to lay stress upon a few symptoms which, in my opinion, point to non-traumatic cases of diaphragmatic hernia. (Because of better evidence these cases must be considered as congenital, whether or not they are remains for later study.)

(a) Pain Immediately After Eating.—Pain after eating has always been a more or less certain symptom of stomach ulcer, and the symptoms of diaphragmatic hernia frequently resemble ulcer (my own case was treated for stomach ulcer for one year), but the farther the pain from the time of eating the more apt we are to be dealing with ulcer. Pain immediately after the ingestion of food, with distress and a sense of fullness, is suggestive of diaphragmatic hernia in which the stomach is herniated.

(b) Paroxysms of smothering and difficulty in breathing attributable to no other cause.

(c) Vomiting coming on with a gush and without premonition.

The objective symptoms, such as the heart being pushed to the right and tympanites over the area where the heart originally lay, together with the foregoing subjective symptoms, should at least suggest diaphragmatic hernia. The X-ray, although a great aid in diagnosing these cases, should not be considered as conclusive in the face of negative findings, as can readily be seen in the picture in which the abdominal contents have returned to their normal habitat.

The treatment consists of closure of the tear in the diaphragm whenever possible either by the transthoracic or transperitoneal route. The route to be chosen is still a question and rests with the individual operator.

I chose the abdominal route because from the X-ray findings I was reasonably sure that there were no tight adhesions—because one picture taken after the patient stood for one-half hour showed the stomach returned to the abdomen—and it is well to try to determine the extent of adhesions by this method. I do not believe in condemning the transthoracic route because of the dangers of artificial pneumothorax—this condition is just as apt to occur through the rent in the diaphragm when the abdomen is opened and in my opinion danger of this condition is overestimated.

In my own case I could not close the tear in the diaphragm by any given procedure: this was due to the adherence of the sac to the surrounding structures. Were it not for the sac, I think that with the exposure which we had the closure could have been accomplished.

In conclusion, I wish to say that from the majority of cases on record the most common site for non-traumatic diaphragmatic hernia is at the oesophageal opening. That a reasonably certain diagnosis can be made, certain enough to warrant an exploratory incision. That the X-ray may be used to confirm the diagnosis, but is useless in the face of negative findings.

THE ASSOCIATION OF MALIGNANT MYOMATA WITH MECKEL'S DIVERTICULUM

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By far the greater number of tumors composed of smooth muscle tissue—the so-called leiomyomata—originate, of course, in the uterus, and it is estimated that between 1 and 2 per cent. eventually undergo malignant transformation.¹ This may be brought about in one of two ways, at least, first, by the development of genuine sarcomata from the connective tissue of the interstitium, and, second, by direct transformation of the muscle fibres, or mesodermal elements, into cells whose histology and vegetative vagaries correspond to the form and behavior of the cells of an autonomous malignant growth. Strictly speaking, this latter type of tumor should not be classified among the sarcomata, but as a malignant myoma. For practical purposes, however, most writers on the subject employ the term myosarcoma to designate a malignant tumor which develops either from the connective tissue framework or from the smooth muscle elements of a leiomyoma. In still other quarters it is maintained that the proliferation of muscle cells occurs primarily in the walls of the blood-vessels with which the tumor is provided.

In addition to the familiar uterine leiomyomata, smaller but histologically identical tumors occasionally are to be observed at autopsy or operation, either singly or in numbers, lying in the musculature of the stomach, intestine, gall-bladder and elsewhere. In our autopsy experience at Bellevue Hospital they occur in less than 1 per cent. of cases and the individual tumors rarely exceed a centimetre in diameter, projecting, as a rule, beneath the serous surface, sometimes into the lumen. They are apt to be regarded as interesting but otherwise negligible. As a matter of fact, there is evidence to show that these apparently insignificant growths undergo malignant transformation with a degree of frequency which entitles them to notice as factors of clinical importance. Although there are but a few cases of so-called myosarcoma of the intestine, stomach and gall-bladder to be found in the literature—five to be exact, a sixth being added in this paper—it is to be recalled that the accidental discovery of apparently innocent leiomyomata in these situations is correspondingly rare. From this it would appear that the capacity of the latter for malignant transformation is proportionately greater than that of their prototype, the uterine leiomyomata. It is permissible, perhaps, to dismiss this phase of the problem with the statement that all extra-uterine malignant myomata originate, not from pre-existing leiomyomata, but

from the mature smooth muscle structures normally resident in the parts concerned. Such an opinion is gratuitous, however, rather than justified by any process of reasoning from established facts.

A case recorded by Ghon and Hintz² exemplifies the probable pathogenesis of the intestinal and related malignant myomata. A man, aged 50, who during life presented symptoms of intestinal obstruction, showed at autopsy 50 or more large and small growths scattered through the wall of the small intestine. Microscopically they were composed of a ground work of cells whose form and arrangement were strikingly like the ordinary leiomyoma, but in addition, there were numbers of large, polymorphous, richly nucleated cells such as commonly are accepted as histological criteria for the determination of malignancy in uterine leiomyomata. In addition, metastatic growths of a closely related histological type were found in the subcutaneous tissues of the abdomen, in the thyroid, lungs, periosteum of the breast bone, in the intercostal muscles, liver, pancreas, adrenals and kidneys, and in the marrow of the femur and vertebrae, together with neoplastic thrombosis of the azygos veins.

The same authors record a case of histologically typical malignant myomatous transformation of a leiomyoma of the jejunum occurring in a man 45 years of age. The tumor was 5½ cm. in diameter and lay between serosa and mucosa. There were no metastases. A third case observed by them was that of a shoemaker, 81 years of age, in whom at autopsy a tumor 15 by 16 cm. was found arising from the greater curvature of the stomach and reaching to the level of the ileocaecal valve. The histological picture was that of a leiomyoma with malignant changes in the muscle cells, and there were metastases from the muscle tumor into the head of the pancreas, the liver, left lung, the left ventricle of the heart and the wall of the urinary bladder. In addition, the subject presented multiple lipomata of the stomach, small intestine and mesentery angiomata of the oesophagus, small intestine and mesentery, and a carcinoma of the fundus of the stomach with metastases which, in places, showed cancer* cells lying directly in the metastatic deposits from the muscle tumor.

A fourth example of extra-uterine malignant myoma is recorded by Landsteiner,⁴ and consisted of a greatly enlarged gall bladder in the walls of which was a massive tumor reaching thence into the substance of the liver. Microscopic examination showed a typical malignant tumor of the sort familiarly described as a myosarcoma. In the liver were numerous metastatic growths of the same histological description. In the mucosa of the gall bladder, on the other hand, was a tumor the microscopic appearances of which were those of an epithelioma with pearl formation.

In the Pathological Laboratories at Bellevue Hospital I have recently had occasion to study a remarkable malignant myoma of identical histology with those just synthesised, but springing from the base of a

*In connection with the extraordinary question of the metastasis of metastases, as recorded by Ghon and Hintz, two examples encountered in Bellevue Hospital³ of the metastasis of independent tumors are of interest. In one patient, a woman, thirty years of age, a myofibroma of the uterus was removed at operation. The patient stated that some months previously a pigmented mole had been removed from the anterior abdominal wall. Section of the uterine tumor revealed two small pigmented nodules in its interior, and these, upon microscopic examination, were found to represent metastatic melanomata. The patient died later of generalized pigmented growths. A second case was that of a woman from whom was removed a massive cystadenoma of the ovary, microscopic examination of the walls of which showed metastatic deposits of melanoma. The patient stated that she had previously been operated upon and a growth removed from one eye.



FIG. 1.—Anterior view of growth. *A*, Walls of diverticulum containing, microscopically, remnants of smooth muscle fibres. Mucosa destroyed. *B*, Cuff of small intestine with well-preserved mucosa and musculature. *C*, Leiomyoma, covered by atrophic but otherwise well preserved mucosa continuous with that of the loop of intestine marked *B*. *D*, Base of the growth showing, microscopically, multiple areas of malignant transformation.



FIG. 2 —Posterior view, showing the lobulated character of the growth and its extension into the walls of the diverticulum above

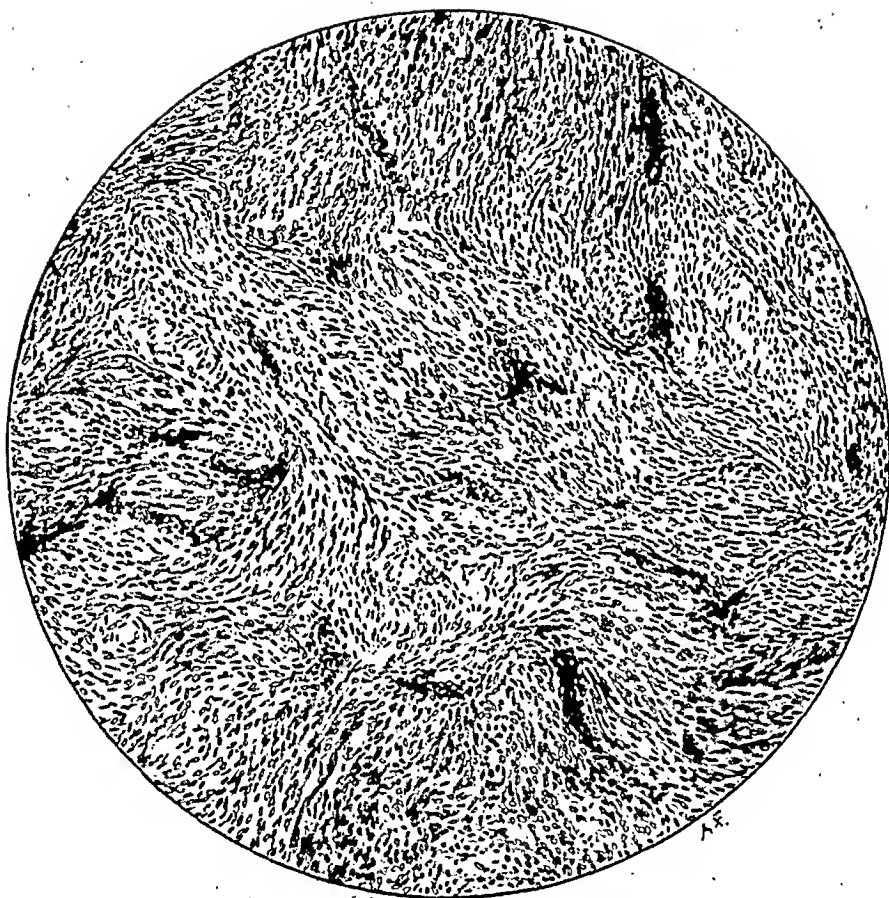


FIG. 3.—Microscopic structure of the intestinal leiomyoma marked C in Fig. 1.

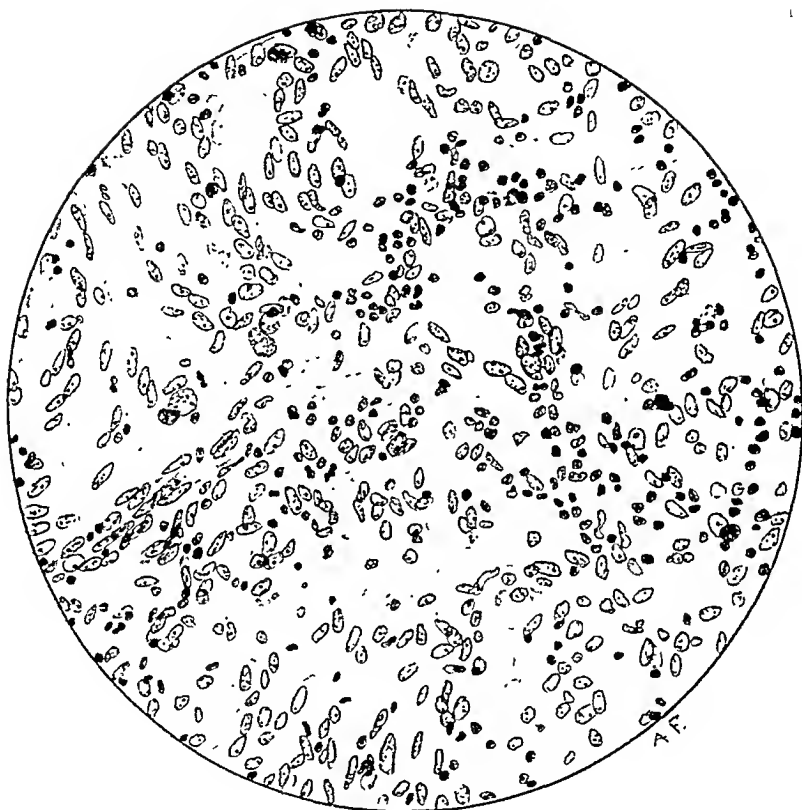


FIG 4.—Microscopic structure of a malignant portion of the growth removed from that part marked *D*₁ in Fig. 1. Note the loose arrangement of the muscle cells, the variations in size and in the form and chromatic richness of the nuclei, together with the presence of a multinucleated giant cell.



FIG. 5.—Microscopic appearance of another part of the same growth (Fig. 1, *D*) showing numerous blood-vessels with thick and well-nucleated walls and an occasional multinucleated syncytial mass lying among the tumor cells, suggesting derivation from the blood-vessel walls.

Meckel's diverticulum of the ileum. The growth occurred in a man, twenty-two years of age. It was discovered by accident in the course of an operation for hernia by Doctor Sweeny. No symptoms traceable to its presence could be elicited.

The specimen, as received in the laboratory, consisted of a mass measuring about 10 cm. in length and 5 in breadth, removed from the convexity of the small intestine, 30 cm. above the ileocaecal valve (Fig. 1). For purposes of description, the specimen is divisible into two parts—an upper, rounded and elastic to the touch, and a lower solid portion. On opening the upper part it was found to consist of a pouch-like formation, lined on the inner side by a roughened, dirty brownish, apparently structureless membrane. The lower portion consisted of a firm, whitish or cream-colored, irregularly lobulated growth, which completely encircled the base of the pouch-like dilatation by which it was surmounted, lobular prolongations from the growth extending upward into the walls of the diverticulum and gradually disappearing therein. On opening the mass it was found that the walls of the diverticulum merged imperceptibly into a cuff-like tube, the lining of which was thrown into small transverse folds of apparently well-preserved intestinal mucous membrane. Projecting into the lumen of this portion of the intestine was a large, pale, firm, whitish tumor, covering the surface of which was a delicate membrane continuous with and presenting the same naked-eye appearances as the cuff of intestine by which the projection was surrounded. Externally the loop of intestine was reinforced by an irregularly lobulated growth, which, on section, presented a smooth, pale surface, where, at intervals, were reddish specks corresponding to injected blood sinuses (Fig. 1, *D*).

Microscopic examination of the wall of the diverticulum showed the presence of a ground substance of connective-tissue, which in places was dense and hyaline in other places moderately fibrillar and more or less richly infiltrated by small round cells. In still other places the connective tissue enclosed quantities of bright yellow pigment, lying in which was an occasional multinucleated foreign body giant-cell. Here and there remnants of smooth muscle bundles were visible. There were no detectable remains of mucosa (Fig. 1, *A*).

Microscopic examination of the tumor projecting beneath the loop of intestine (marked *C* in the illustration) showed the histology of a typical leiomyoma; that is to say, the growth was made up of a number of small, spindle-shaped cells arranged in intercommunicating bundles or whorls, the whole supported by a delicate reticulum of connective tissue, the former staining yellowish by the Van Giesen method, the latter reddish (Fig. 3). The surface of this part of the growth was covered by an atrophic but otherwise well-preserved layer of intestinal mucosa.

Microscopic preparations were made from the base of the growth—that part marked *D* in Fig. 1. The tissue was cut in frozen sections or in celloidin, and stained with hæmatoxylin and eosin and by the method of Van Giesen. Microscopic examination revealed a groundwork the histology of which was not to be distinguished from that of a moderately cellular leiomyoma, such as commonly is encountered in the uterus—intercommunicating bundles of spindle-shaped muscle cells, with cigar-shaped nuclei supported by a delicate reticulum of connective tissue. At fairly frequent intervals, however, were areas in which the compact fibro-muscular structures merged into groups of polymorphous cells, which were arranged loosely and without any semblance of order. Their nuclei varied in shape and chromatic richness, and among them multinucleated giant-cells were fairly common (Fig. 4). In still other places the growth was composed of cellular areas in which blood-vessels were numerous, the walls of the individual vessels being thickened and unusually well nucleated. In such areas multinucleated syncytial masses were occasionally to be seen lying among the tumor

cells (Fig. 5). Some of the multinucleated masses were of such character as to indicate that they might have been separated from the vascular wall, others were of the same type as the multinucleated cells seen in other parts of the growth.

I have been able to find but one case of like origin in the literature of medicine,⁵ that is to say, a malignant myoma or so-called myosarcoma of Meckel's diverticulum. The patient was a fifty-five-year-old individual who became more and more cachectic without a clinically discoverable cause, and finally died. At autopsy a massive tumor was found arising from a point opposite the mesenteric attachment of a Meckel's diverticulum of the jejunum. The lumen of the diverticulum communicated with that of the intestine, through the medium of a tubular structure which was lined on the inside by intact mucosa and whose muscular coats were continuous with those of the jejunum. The growth in the diverticulum was made up of numerous whitish, firm nodules with areas of softening and hemorrhage. Microscopic examination of the tumor showed what was described as a fibromyosarcoma. The abdomen was filled by serous fluid. The liver was riddled with metastatic deposits and the lymph-nodes in the region of the primary focus were completely transformed into tumor tissue.

With the exception of a casual statement by Kaufmann⁶ to the effect that "the Basle collection contains a spindle cell sarcoma of Meckel's diverticulum the size of a hen's egg that was found in a seventy-two-year-old woman" I have been able to find but one remaining example of a neoplasm originating in an intestinal diverticulum, namely, a case recently recorded by Black.⁷ In fact, true tumors of genuine Meckel's diverticula are apparently among the rarest of rarities. So-called enterocystomas, on the contrary, are fairly common. Black's tumor weighed 4260 gm. and was removed from the tip of a diverticulum in the sigmoid region. The growth was examined by MacCallum, who pronounced it papillomatous. While it is not to be denied that this is an unusual situation for Meckel's diverticulum, the malformation in question has nevertheless been described there.

CONCLUSIONS

1. Subserous, occasionally submucous leiomyomata are encountered in the walls of the stomach, intestine or gall-bladder in less than 1 per cent. of autopsies. As a rule, they are solitary, rarely multiple. Seldom do they exceed a centimetre in diameter.

2. Judging from the small number of cases to be found in the literature of malignant myomata of the stomach, intestine and gall-bladder, and comparing this with the number of subserous or submucous leiomyomata met with in corresponding situations in the routine performance of autopsies, the assumption seems reasonably justified that these apparently insignificant growths undergo transformation into malignant

myomata with a degree of frequency which entitles them to attention as a potential source of danger. If accidentally encountered at operation, they should, I think, be removed.

3. The majority of malignant myomata of the stomach, intestine and gall-bladder thus far reported were found in organs which otherwise appeared to be intact. In other and rare instances, however, these malignant growths bear a definite anatomical relationship to the developmental malformation of the intestine familiarly known as Meckel's diverticulum.

4. The malignant myomata of the stomach, gall-bladder and intestine, including those associated with Meckel's diverticulum, are capable not only of extensive local expansion, but of widespread metastasis. Their degree of malignancy is apparently in excess of that of their prototype, the malignant myomata developing from smooth muscle tumors of the uterus.

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- ³ Symmers: *Interstate Med. Journ.*, vol. xxiv, No. 10, p. 979.
- ⁴ Landsteiner. *Zeitschrift f. klin. Med.*, vol. lxii, 1907, p. 427.
- ⁵ Fried, *Inaug. Dissert.*, Erlangen, 1902.
- ⁶ Kaufmann, *Spez. path. Anat.*, vol. i, 6th ed., p. 465.
- ⁷ Black, *Surg., Gynec. and Obstet.*, May, 1919, p. 473.

the pneumococcus or the streptococcus or both, the similarity with our own 3 cases seems perfectly evident.

In these 4 cases we find influenza followed by a secondary infection limited to the recti muscles without any of the general symptoms or of the multiple lesions that usually accompany pyæmic processes.

We are at once reminded of the degeneration of the abdominal muscles which has been often noted as a complication of typhoid fever, was first described by Zenker in 1864 and bears his name, and which has been fully described by our own Doctor Keen in his Toner Lecture on the Surgical Complications of Typhoid in 1876.

In a series of autopsies performed during the influenza epidemic at Camp Devens by Dr. S. Burt Wolbach, lesions precisely similar to those described in typhoid were noted in nine cases. They ranged from a swollen opaque yellowish-white appearance to the presence of large masses of blood clot occupying considerable areas of the recti muscles. The following extracts from the autopsy reports show the extent of the observed lesions:

CASE I (September 30).—H. N. R. Recti for 8 cm. above pubes are swollen and infiltrated with blood clot, and muscle is softer and more friable than normal.

CASE II (October 1).—J. C. Recti from umbilicus to pubes swollen, and upper half of each is infiltrated with dark red blood clot. Fibres are widely separated and the cavities 0.5 to 1 cm. in diameter filled with clot. Pubic ends of muscles are pale, opaque and friable.

CASE III (October 3).—E. G. Lower 8 cm. of recti opaque, pale, friable, yellow, and in the left small areas of hemorrhage 0.2 to 1.2 cm. long separating muscle fibres at junction of normal and yellow portions.

CASE IV (October 4).—G. P. Lower 8 cm. both recti swollen opaque, yellowish white and friable.

CASE V (October 4).—M. L. Muscles and chest normal except lower end left rectus is opaque, yellowish and slightly swollen for distance of 2 cm.

CASE VI (October 7).—C. W. Upper part of recti streaked in pale grayish red lines and on the right side are punctate hemorrhages.

CASE VII (October 8).—F. LeC. Lower ends of both recti from umbilicus to pubes greatly distended with dark red blood clot, and the retroperitoneal tissue on each side is infiltrated with blood for a distance of several cm. Muscles on section are soft, paler than normal, with large masses of blood clot separating fibres longitudinally and occupying spaces between transverse tears of the fibres.

CASE VIII (October 11).—A. H. Lower one half rectus contains yellow opaque areas of striæ; on section portions of the muscle 1 to 2 cm. in length and 0.5 cm. in width are greenish yellow in color, opaque,—small areas of hemorrhage in muscle substance. Similar conditions at upper end right rectus.

CASE IX (October 11).—W. J. E. Recti at extreme ends pale reddish gray or pink; no hemorrhage.

In the microscopic study of sections of muscles removed at autopsy Doctor Wolbach informs me that similar changes, though much less marked, are present in the other abdominal muscles and in other muscles of the trunk, such as the pectorals and the latissimus dorsi, though rupture of the muscle with accompanying hemorrhages, except microscopic, were not observed.

It seems probable that an abscess occurring beneath the lower angle of the scapula, following influenza and operated on before our attention had been drawn to these muscle changes, was of the same character, but it has not been included, because its exact nature was not recognized.

From these observations it seems quite clear that a Zenker degeneration of the recti muscles is a not infrequent accompaniment of influenza and influenza pneumonia, that the muscle fibres become so friable that rupture occurs with varying degrees of hemorrhage, and that more rarely still the blood clot may be infected by means of the predominant organism with resulting abscess.

These cases of secondary infection, those alluded to in the earlier part of this paper, as well as those limited to the recti muscle, suggest one problem of more than mere speculative interest.

Is there a definite selective action on the part of different organisms or different varieties of the same organism for different tissues as claimed by Rosenow?

Our observations at Camp Devens showed that we were dealing with an organism that attacked the pericardium frequently but not the endocardium; the structures around the joints, but not the bones or the joints themselves; the striped muscles, but not the unstriped; connective tissue, but not glandular; the abdominal wall, but not its contained viscera. Although, of course, satisfactory proof is still wanting, it hardly seems as if this selection could be purely accidental.

INDICATIONS FOR OPERATION IN URETERAL CALCULI

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THE discussion of the question whether or not to operate upon a case of ureteral calculus was a much easier task ten years ago than at the present time. This change in viewpoint is in great measure due to the rapid development of the non-operative methods of treatment, with which every surgeon should not only be familiar but give his patient the benefit of, before operation is considered.

The only exception to this rather dogmatic statement is in those cases to which I shall refer later, where the symptoms of renal infection predominate.

Even in this group of cases, an expectant plan of treatment is often rewarded by the subsidence of the acute symptoms, thus enabling one to deliver the calculus in the interval by one of the non-operative methods.

A correct diagnosis and a knowledge of the pathological changes which a ureteral calculus can cause are essential. At first glance it would seem as though it were superfluous to mention the necessity of such fundamentals. To one who has experienced the chagrin of operating upon a supposed calculus, and finding that the shadow was due to some extra-ureteral cause, such advice will not seem out of place. In a recent paper¹ I have compared the value of clinical evidence with that obtained through the employment of our modern diagnostic methods. The latter far outweigh the former for a number of reasons: (1) Experience has shown that there are many other causes for the symptoms formerly regarded as pathognomonic for ureteral calculus, namely, the so-called renal colic syndrome; (2) many ureteral calculi belong to the latent group which only give rise, as in one of the cases to be quoted later, to symptoms when infection of the kidney supervenes; (3) there are many extra-ureteral shadows which can deceive even the trained eye by their simulation, as to form, size and position, of a true intra-ureteral calculus. In the article referred to, I emphasized the necessity of utilizing every possible modern method of diagnosis. The ordinary X-ray single-plate method has been superseded in doubtful cases by the use of the stereoscopic exposures. The insertion of the opaque ureteral catheter was formerly considered to be all that was necessary to differentiate an intra- from an extra-ureteral shadow, but this led to erroneous conclusions in a sufficiently large number of cases as to force upon us the additional use of opaque solutions to fill the ureter and prove that the shadow was intra-ureteral by the fact that the ureterogram revealed either a nodular enlargement at the point of lodgement of the calculus or a uniform dilatation of the ureter proximal to the seat of obstruction.

A knowledge of the sequelæ of the presence of a calculus in the ureter is

¹Diagnosis of Ureteral Calculi. *Surgery, Gynecology and Obstetrics*, 1918, 27, 461.

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no less important to the proper comprehension of the indications for operation than the value of a correct diagnosis.

The following are the most common sequelæ:

1. In the ureter: (a) uniform dilatation above calculus; (b) stricture formation at point of impaction; (c) peri-ureteral abscess.

2. In the kidney: (a) pyelonephritis; (b) infected or non-infected hydronephrosis; (c) perinephritic abscess; (d) calculous anuria; (e) generalized sepsis (bacteræmia).

Some of these require special mention. The dilatation of the ureter occurs, as a rule, above the point of impaction of the calculus. Occasionally,

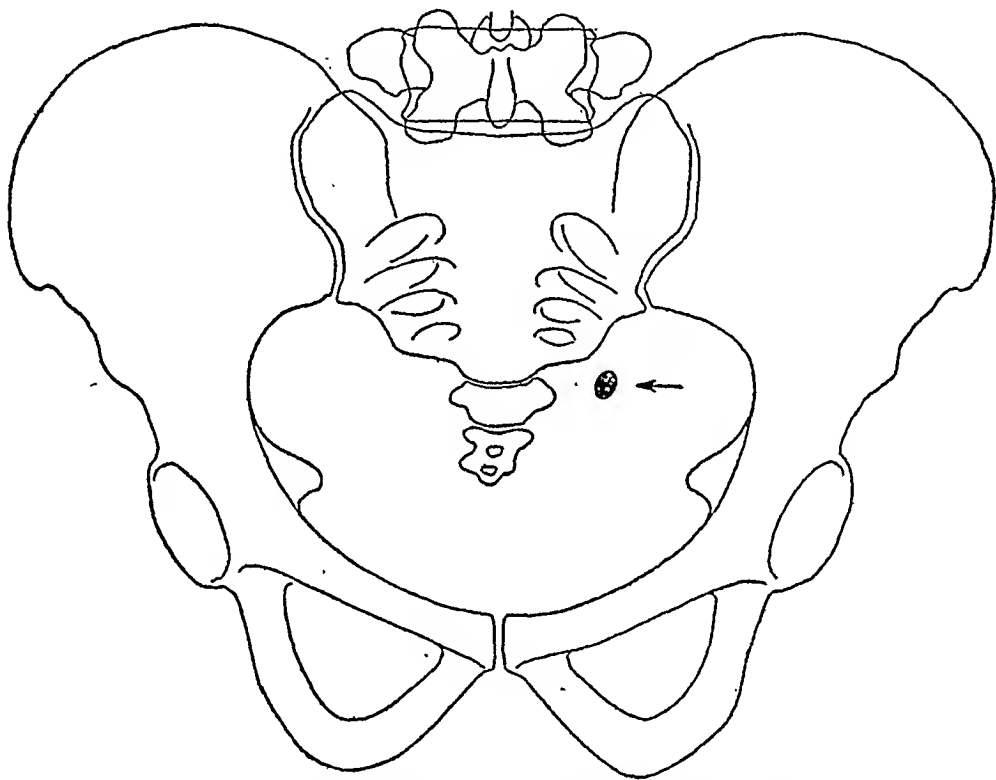


FIG. 1.—Arrow points to location of calculus in Case I of fruitless colics in which delivery of calculus by cystoscopic manipulation and injection of oil and albolene into the ureter was unsuccessful.

however, a spindle-shaped dilatation of the ureter is found, as in a case recently reported by Lower. Under these conditions we may have what is known as a wandering or floating calculus, which at times seems to be in the upper end of such a dilatation, yet when the ureter is explored at this point the calculus may have dropped down to the lower end of the dilatation and *vice versa*.

Stricture formation may not only occur as the direct result of the lodgement of a calculus at a given point, but has been known to follow a ureterotomy. At times a fistula may follow removal of a calculus from such a strictured area as in one of the cases to be cited later. A peri-ureteral abscess is not a frequent complication, but there are a number of cases on record where a stone has ulcerated its way through the wall of the ureter

and has been found lying in the abscess cavity in close contact to the ureter or in the fistulous tract. The name "migrating calculus" has been given to this complication.

The kidney complications are of especial interest for the reason that catheterization of the ureter upon the side where a calculus is lodged is not always an easy task. Not infrequently we are obliged to remain ignorant of the exact condition of the corresponding kidney because we have been unable to secure urine directly from it or to make a pyelogram in order to determine the degree of dilatation of the renal pelvis or destruction of the parenchyma. Thus, as I will show by one of the cases to be quoted, our efforts at

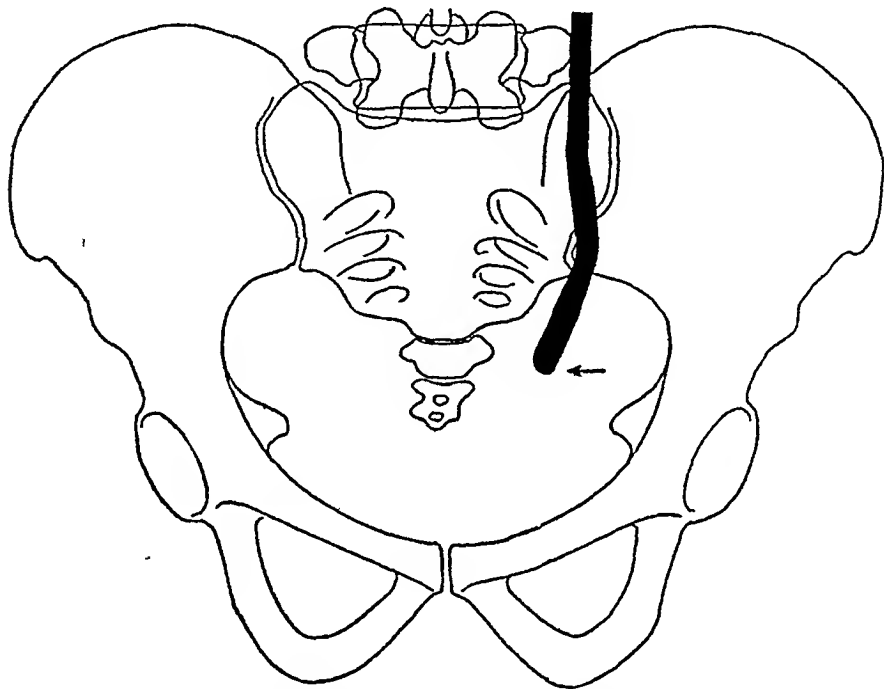


FIG. 2.—Ureterogram showing dilatation of ureter above point of impaction of calculus in same case shown in Fig. 1. Arrow points to location of calculus at lower end of ureterogram.

conservatism following removal of a calculus with complicating renal infection, are often defeated by our inability before operation to determine the exact nature of the pathological changes in the kidney.

I believe that I can best illustrate the most frequent indications for operation by citing some typical cases selected from my records:

GROUP I. FRUITLESS COLIC CASES IN WHICH NON-OPERATIVE METHODS
HAVE FAILED TO DISLodge THE CALCULUS

CASE I (No. 1584).—Male, aged thirty-three years. Typical ureteral colics at intervals for preceding two years. Examination showed an oval shadow (Fig. 1) just above bladder on left side of true pelvis. Use of X-ray catheter supplemented by ureterogram and stereoscopic

INDICATIONS FOR OPERATION IN URETERAL CALCULI

X-ray pictures showed shadow to be intra-ureteral. Ureter considerably enlarged (Fig. 2) above point of lodgement of calculus. Turbid urine containing many pus corpuscles escaped alongside catheter introduced beyond calculus in left ureter. Two attempts made to remove calculus using 2 per cent. papaverin with olive oil at one sitting and albolene at next. No change in position of shadow. Ureterotomy deemed indicated. Calculus about size of a navy bean, very firmly fixed in pelvic ureter just above bladder. Unable to push stone into bladder and could be only brought a short distance upwards with great difficulty. Uneventful recovery.

This case is an example of so-called fruitless colic. The position of the calculus had not changed in spite of a number of attacks during the preceding two and one-half years.

My standpoint at the present time is that one is not justified in operation upon such a case, especially if the stone lies in the pelvic portion of the ureter, until repeated attempts have been made to deliver it by one of the manipulative methods so familiar to urologists.² These methods may be enumerated as follows:

1. Injection of 2 per cent. papaverin alone.
2. Injection of 30 c.c. of albolene, glycerine or olive oil.
3. Injection of 1 and 2 combined.
4. Use of the Lespinasse laminaria tent.
5. If the stone is lodged in the intraparietal portion of the ureter, use of the Bransford Lewis or similar dilators and forceps, even if necessary to incise the mucosa of the ureteral orifice in the case of a calculus presenting at the vesical end of the ureter.

GROUP II. URETERAL CALCULI COMPLICATED BY A MORE OR LESS SEVERE DEGREE OF RENAL INFECTION

CASE II (No. 1162).—Female, aged twenty years. Left ureteral calculus with pyelonephritis. Ureterotomy followed by fistula due to stricture at point of lodgement of calculus. Nephro-ureterectomy for infected hydronephrosis.

Patient never had any symptoms until three days before admission, then had fever and pain in left upper abdominal quadrant radiating down ureter. No urinary signs. On admission left kidney was found enlarged and tender. Shadow like that of a bicuspid tooth in pelvic ureter (Fig. 3). Fever subsided in a few days after admission. Ureterotomy after eight days of normal temperature. Calculus found firmly impacted in pelvic ureter just below iliac vessels. Ureter very much thickened at point of impaction. Moderate degree of fever for eight days after this operation. Left hospital with sinus leading to ureter. Returned four weeks later with history of sudden recurrence of left renal pain radiating downwards with chills and fever. Large

² If a slight renal infection is present (see Group II) it is justifiable to make one or more efforts to dislodge and deliver the calculus. If much fever, however, is present, operation is indicated at once (see Case No. IV).

amount of turbid urine escaped from fistula at lower end of former ureteral incision. Cystoscopy revealed a marked cystitis. Ureteral catheter and bougies completely obstructed one and one-half inches above bladder. Ureter exposed, found size of adult finger, very hard with impermeable strictures below fistula. Ureteral plastic or reimplantation impossible. Kidney found much enlarged by palpating through ureteral incision. Kidney and ureter down to point of obstruction removed and found to be the seat of a very marked infected hydronephrosis (Fig. 4).

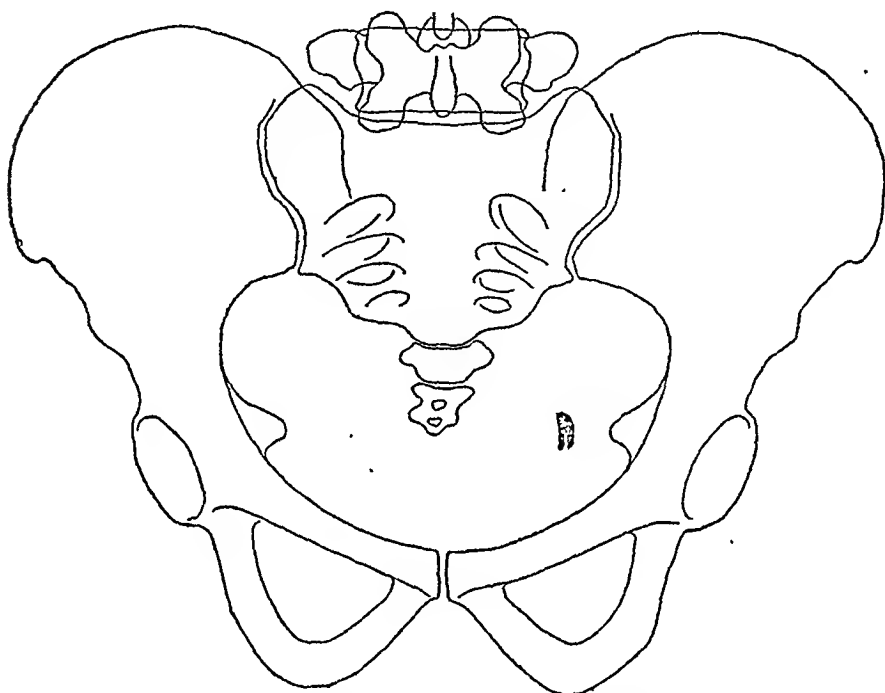


FIG. 3.—Location of tooth-shaped calculus in Case II.

This case illustrates an absolute indication (*a*) when the patient entered for the second time, on account of the evidences of infection of the kidney, and (*b*) an absolute indication for operation of the ureteral fistula.

CASE III (No. 269).—Male, aged thirty years. Symptoms of acute sepsis without localizing signs due to calculus impacted in upper end of ureter. Was well until five days prior to admission, when had chills, high fever and tenderness over kidney. X-ray examination showed shadow in lumbar portion of the left ureter (Fig. 5). Operation revealed a marked pyelonephritis with calculus impacted in lumbar ureter just below renal pelvis. Uneventful recovery, after nephrectomy and removal of calculus in lumbar ureter.

I have seen quite a number of similar cases in which the ureteral calculus had remained latent until the renal infection gave rise to the clinical picture so characteristic of that condition. This case illustrates the necessity

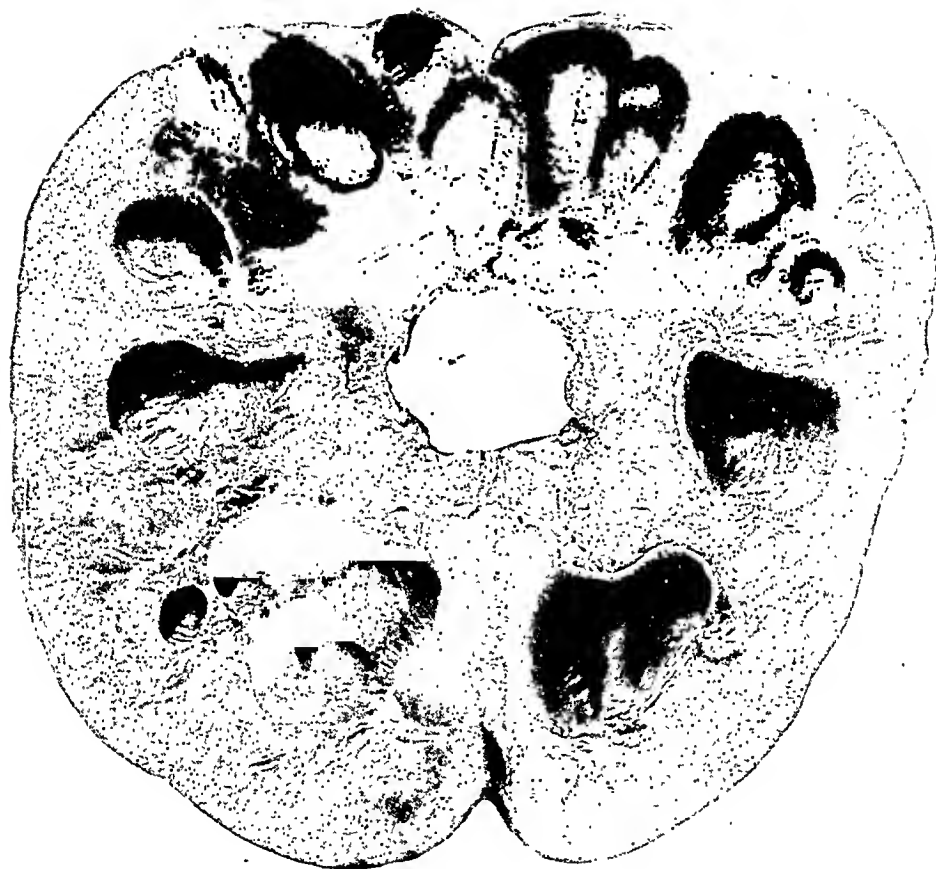


FIG. 4.—Kidney showing marked degrees of infected hydronephrosis due to impaction of calculus in pelvic portion of ureter (from Case II). Note dilated calyces and dark color due to intense infection of same.

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of a routine X-ray examination of the urinary tract in all cases of sudden onset of febrile symptoms, with or without localizing signs, or even with those pointing to renal infection.

The following case illustrates how difficult it is to be conservative when renal infection complicates a ureteral calculus:

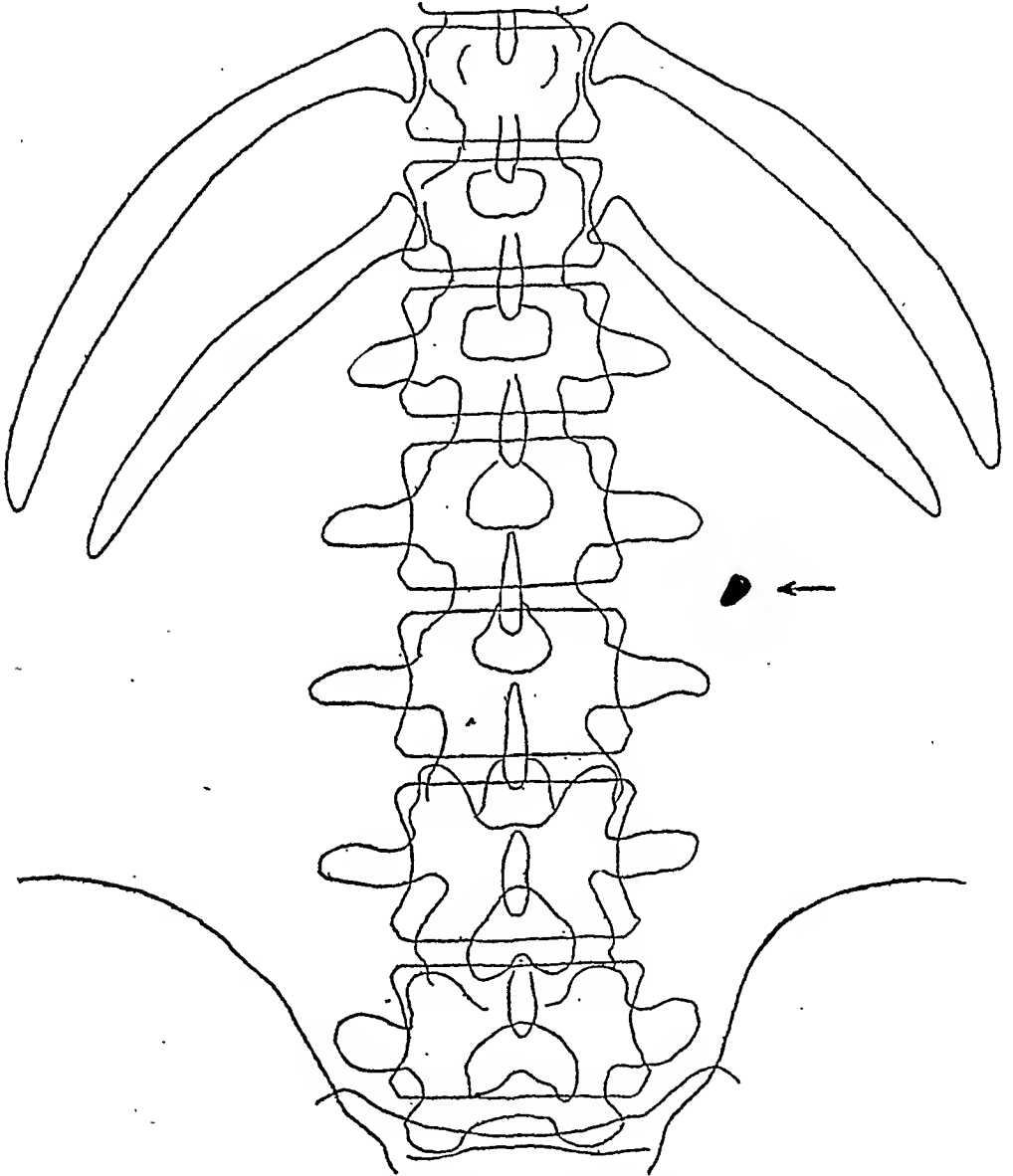


FIG. 5.—Location of calculus in Case III. Arrow points to calculus in lumbar portion of ureter. Symptoms of a severe renal infection completely obscured those due to a ureteral calculus. This case shows the necessity of taking X-ray pictures of the urinary tract in cases of renal infection.

CASE IV (No. 1491).—Male, aged forty-four years. Impacted calculus in left pelvic ureter. Severe renal infection not relieved by removal of calculus. Ureteral colics for two years before admission. Another attack about four weeks before being first seen, accompanied by fever and chills. No enlargement or tenderness of kidney. X-ray revealed triangular shadow in left pelvic ureter (Fig. 7). Able to pass catheter beyond calculus. Thick pus escaped. In the effort to save

the kidney the calculus was removed (Fig. 8), but the temperature persisted, requiring later nephrectomy. Large perinephritic abscess found at upper pole of kidney and extensive pyelonephritis.

It is very difficult to consider cases in Group II as a whole. The necessity of individualizing in each case is very apparent to those who have had much experience with renal infection. The tendency at the present time to be conservative and to try to save as many kidneys as possible by removing the cause of obstruction in the ureter, is not always rewarded by a cessation of symptoms. Case IV well illustrates this, because in addition to the infection in the renal pelvis and the parenchyma which might have yielded

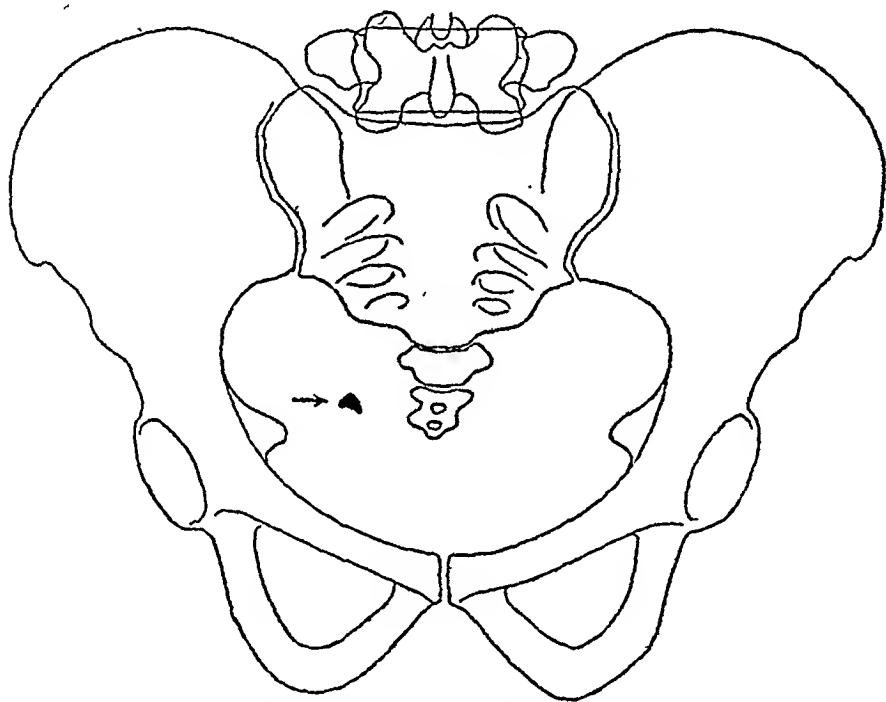


FIG. 7.—Location of shadow from Case IV of impacted calculus in pelvic portion of ureter. The severe renal infection was not relieved by removal of the calculus. Arrow points to calculus.

to better drainage after removal of the calculus, a perinephritic abscess was present. As the result of this latter complication the septic condition continued in spite of good ureteral drainage following the ureterotomy.

Much depends on the acuity of the symptoms and the degree of involvement of the kidney as determined by ureteral catheterization, functional tests and pyelography. If the clinical evidences of renal infection in the shape of fever, etc., are not very acute we are only justified in operating if either the expectant or non-operative methods of treatment are unsuccessful. I have had a number of cases with slight rise of temperature (100° to 101° F.) and a moderate degree of pyuria which have subsided completely after non-operative delivery of the calculus. In one of these cases which I have re-

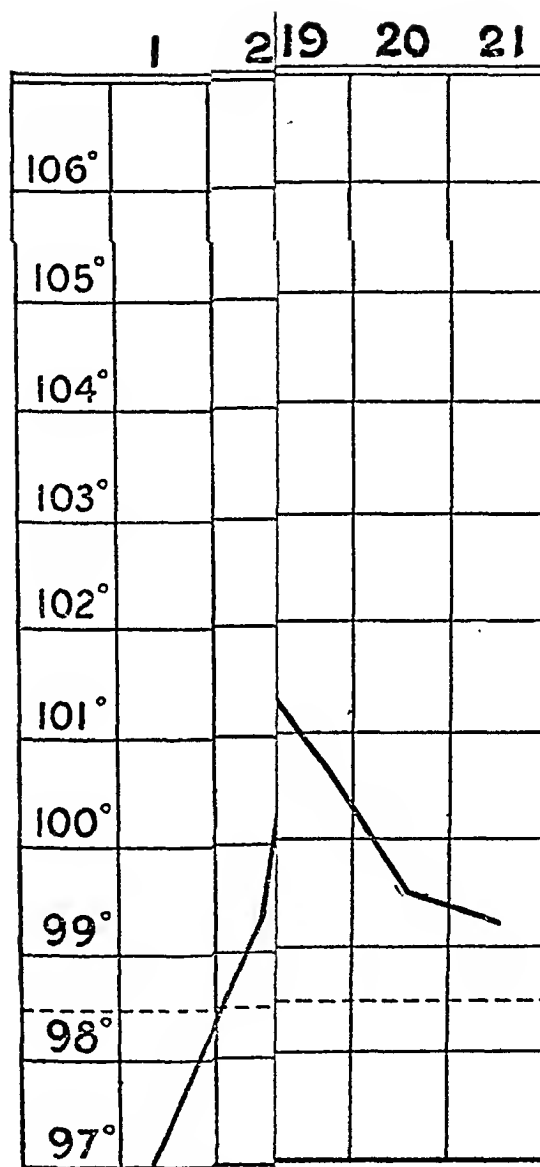


FIG. 6.—Temperature as discovered at operation.

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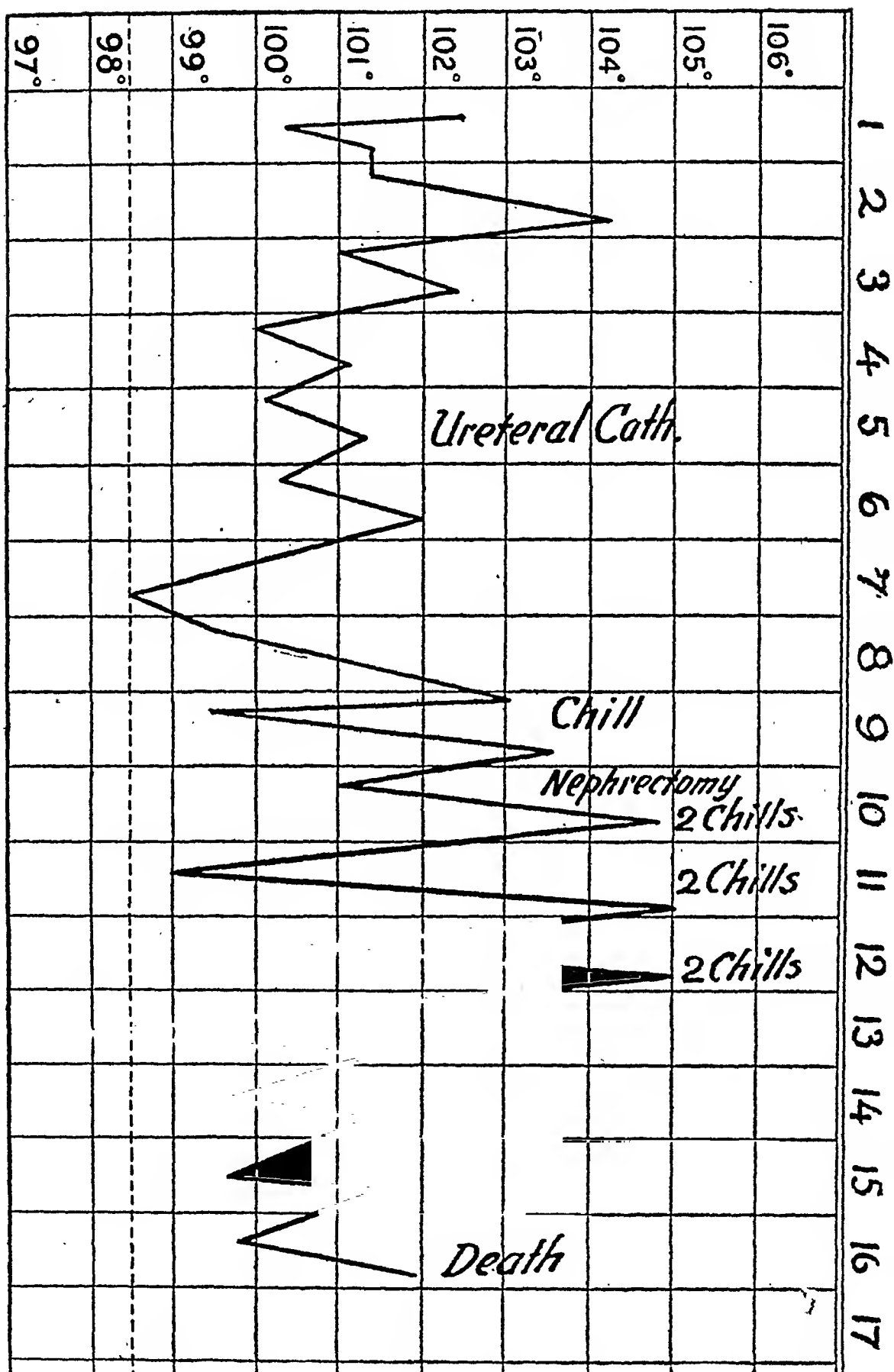


FIG. 9.—Temperature chart from Case V in which symptom of severe bacteremia followed ureteral catheterization.

ported in the article above referred to,³ it was very difficult at first to determine whether the calculus had been passed after the injection of albolene, owing to the fact that there were also a number of extra-ureteral shadows present. This is something to be borne in mind before operative treatment is considered. If the symptoms of renal infection are very acute, I do not believe it is advisable to take any chances with conservative treatment, if after a reasonable period of waiting, the symptoms of renal infection persist. Ureterotomy alone will suffice if the kidney is in good condition. Nephrectomy is imperative as an additional measure at the time of performing the ureterotomy if the various diagnostic methods referred to above reveal a badly damaged kidney. Even under these conditions it is often wise to be conservative, as a secondary nephrectomy can be easily performed if we do not wait too long for the clinical evidences of subsidence of the renal infection. This is especially true where calculi are present in both ureters and in cases where there is a history of the passage of calculi on previous occasions and finally if our functional tests and ureteral catheterizations show that the opposite kidney might possibly not be capable of doing double work.

In this connection let me quote a case which shows how easily one can be misled by a negative X-ray when a ureteral calculus is present in addition to renal infection.

CASE V (No. 1333).—Male, aged thirty-three years. Gave history of recurrent attacks of right ureteral colic during preceding two years with hematuria and chills followed by profuse perspiration. Upon entering hospital temperature was 102°, and urine contained moderate amount of pus. Two X-ray examinations were made, but the report from the radiographer was that no calculi were present. Thinking that the case was one of renal infection alone, a ureteral catheterization was done about one week after entrance to the hospital during a practically afebrile period. An obstruction was met with in the lumbar portion of the ureter. Streptococci and staphylococci were found in pure culture from both sides. Indigo-carmin appeared on both sides in five minutes. A diagnosis of bilateral renal infection was made, and expectant treatment advised. Much to our surprise, he had a severe chill on the fourth day following the ureteral catheterization, which was followed by an extremely septic condition (Fig. 9), and death eleven days after ureteral catheterization. Upon reexamination of the X-ray plates we found that the radiographer had overlooked a faint, small, round shadow in the line of the lumbar ureter. This was the cause of the obstruction which we encountered in the course of our ureteral catheterization on this side.

I quote the case to show that ureteral catheterization may be followed by serious consequences when performed during the acute stage of renal infection and an impacted ureteral calculus is present.

A nephrectomy was performed in this case after the second day of the

³ Diagnosis of ureteral calculi. *Surgery, Gynecology and Obstetrics*, 1918, 27, 461.

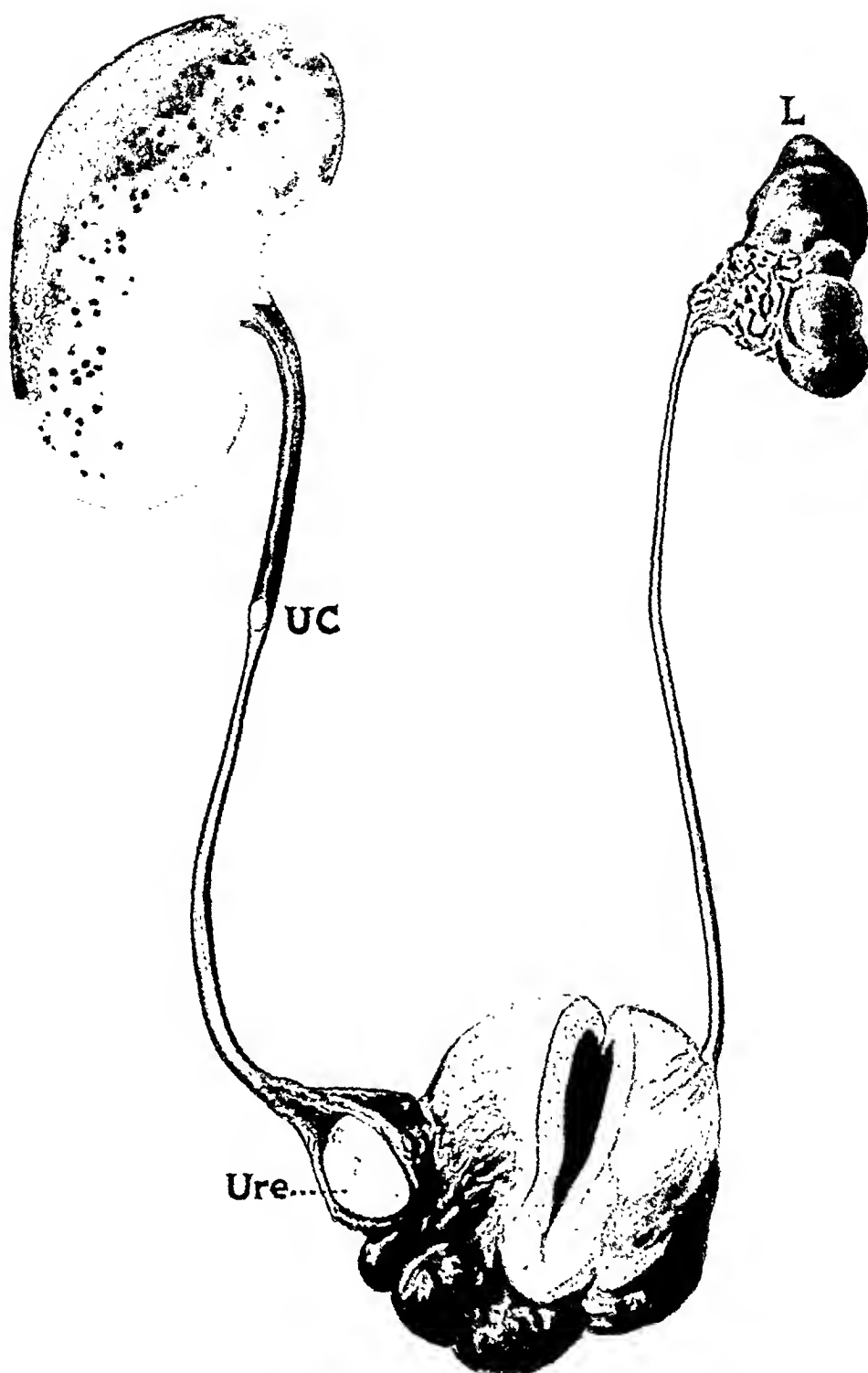


FIG. 10.—Specimen removed at autopsy, showing calculus (UC) in lumbar portion of right ureter completely blocking same. Above point of impaction of calculus the ureter is greatly distended and the kidney is the seat of an extensive pyelonephritis. At lower end of the same ureter (Ure) were two calculi in close proximity to the ureter but lying in a congenital diverticulum of the bladder. The opposite (left) kidney was of a rudimentary type, so unable to do the work thrown upon it by the blocking of the right ureter.

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onset of acute sepsis and the kidney showed the picture of an acute diffuse infection. Cultures taken showed *B. coli* alone. This case teaches the necessity of studying an X-ray plate, preferably a stereoscopic one in a dry condition, as faint shadows due to uric acid calculi may be easily overlooked.

In a recent case referred to in my preceding paper,⁴ I was able to intensify such a shadow by injecting collargol into the ureter, which was absorbed by the calculus, thus enabling us to see it distinctly.

GROUP III. CALCULOUS ANURIA CASES

These constitute an absolute indication for operative treatment unless non-operative delivery is immediately successful. I do not believe, however, that one should waste any time unless the anuria cases are seen in the first few days. The period of tolerance in calculous anuria, *i.e.*, before uræmic symptoms supervene, varies somewhat, and one cannot afford to take any chances by relying upon a fixed time for these fatal symptoms to appear. The average period of tolerance, *i.e.*, before uræmia supervenes, is six to eight days after the onset of the anuria, so that there is no justification at the present time for operating upon these cases before a thorough urological study has been made of the location of the calculus and the condition of both kidneys, since these cases may be easily taken to a hospital where such facilities are at one's disposal. This anuria, according to Cabot, may occur in one of four ways: (1) The blocking of both ureters practically simultaneously by calculi; (2) the blocking of the only ureter; this may occur in (a) cases of solitary kidney, (b) where the opposite kidney has never developed⁵ or has been destroyed by disease, and (c) in cases of fused ureter with two kidneys; (3) by the blocking of the ureter of the better of two damaged kidneys with the occurrence of reflex anuria in the damaged kidney on the opposite side; (4) by the blocking of the ureter on one side with reflex suppression on the other side though the kidney is sound. This last-named class of cases is still in dispute.

GROUP IV. BILATERAL URINARY CALCULI

Here, I believe, it is best to try to deliver the calculus by non-operative means on both sides if such a procedure is possible before operation is considered.

Bilateral ureteral calculi alone without concomitant renal calculi occur so infrequently that it is best to consider the two together, and I believe the indications have been best given by Braasch⁶ in a recent paper, as follows: (a) The kidney with acute complications should be operated on first; (b)

⁴ Diagnosis of Ureteral Calculi. Surgery, Gynecology and Obstetrics, 1918, 27, 461.

⁵ I reported a case of calculous anuria in which the opposite kidney was rudimentary and the only functioning kidney blocked by calculi in ANNALS OF SURGERY, 1908, 48, 703.

⁶ Lithiasis with Bilateral Renal Involvement. Boston Medical and Surgical Journal, 1918, 178, 292.

without acute complications the kidney with the better function should be operated on first; (c) occasionally simultaneous bilateral operation is advisable.

CONCLUSIONS

Operative interference is indicated in the following cases:

1. When colics recur or infection persists after repeated attempts have been made to deliver the calculus by non-operative methods and there is practically no change in the location of the calculus.

2. When there are evidences of stricture formation following (a) the spontaneous expulsion of a calculus, (b) or its delivery by non-operative methods, or (c) after a ureterotomy (Case II).

3. When a fistula is present either (a) as the result of perforation of the ureteral wall by a migrating calculus, or (b) above a stricture (Case II).

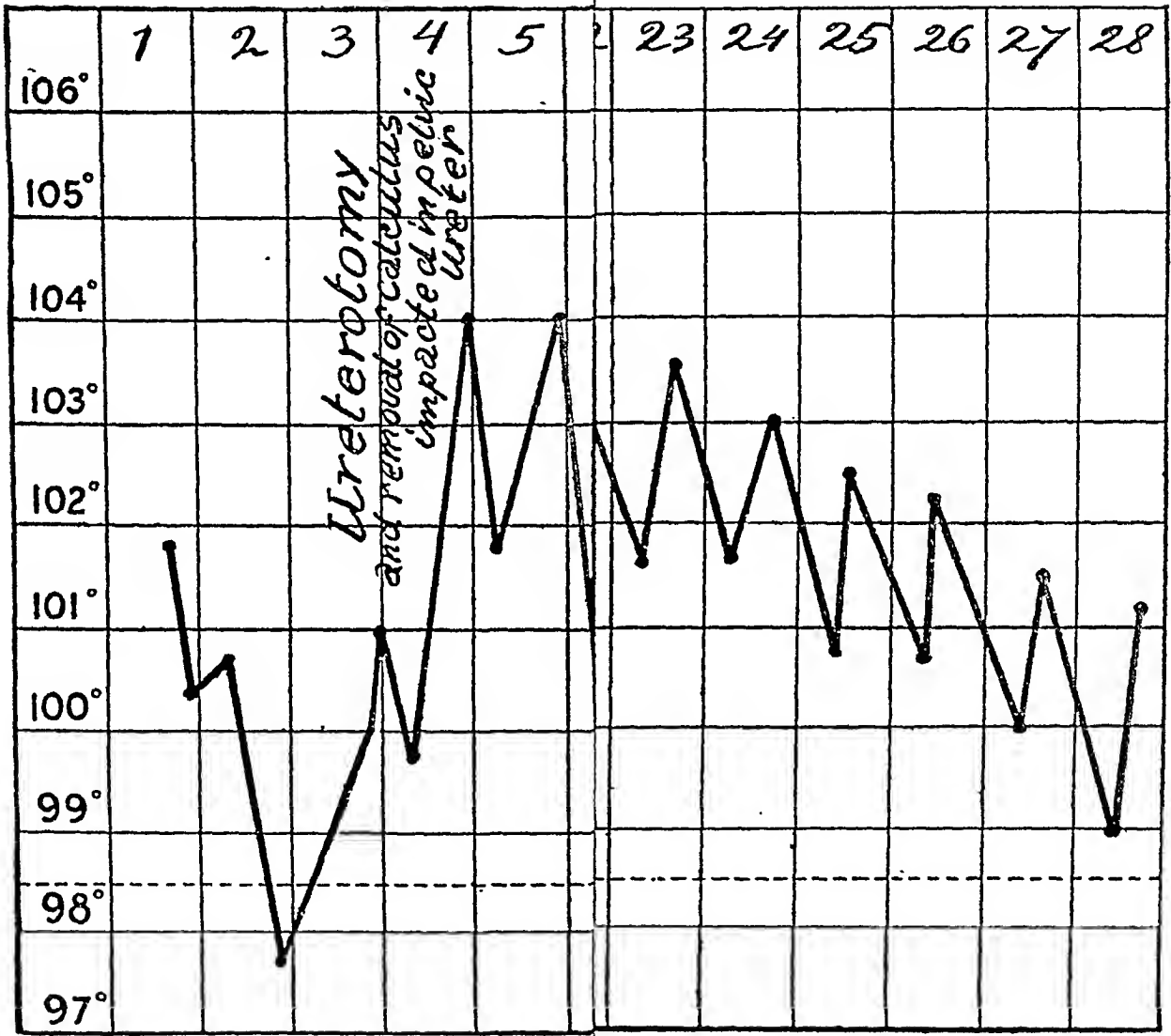
4. When a severe degree of renal infection is present and the calculus is impacted in the ureter (Cases III and IV). Whether or not it is necessary to remove the kidney in addition to the ureterotomy depends on the degree of involvement of the renal pelvis and parenchyma. Some of these cases are complicated by a peri-ureteral or perinephritic abscess which will require immediate drainage.

5. Calculous anuria cases should be operated upon as soon as the diagnosis of the location has been made. The average period of tolerance is six days. If the calculus is located near the vesical end of the ureter an attempt to deliver the calculus by manipulation is worthy of a single trial, but one should not lose valuable time by postponing operative interference too long while such an attempt is being made.

6. In cases of either aseptic or infected hydronephrosis (uronephrosis) immediate operation is indicated. As a rule, the degree of dilatation of the renal pelvis is such that a nephrectomy is necessary. If pyelography can be done in such cases, it gives the best picture of the extent of destruction of the parenchyma.

7. Many of the cases in which an attempt has been made to save the kidney may be benefited by catheter drainage, as suggested by Caulk, or renal pelvic lavage.

8. The indications in cases of bilateral calculi are given in the corresponding group (see above).



SOME DIFFICULTIES IN THE DIAGNOSIS AND TREATMENT OF UNILATERAL RENAL TUBERCULOSIS

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IN employing the term Primary Renal Tuberculosis one refers to a state of primarity of the infection, only in respect to the site of its initial appearance in the urogenital system. The fact is well established that the several parts of this system are almost invariably infected by micro-organisms which are either blood-borne from some distant and truly primary focus, or more rarely by contiguity. In the vast majority of cases of tuberculosis of the genito-urinary system of the male, the tubercle bacilli find primary lodgment either in one or other kidney, or in the globus major of the epididymis. In these locations the bacilli find a favorable soil for development, which development proceeds in the majority of instances, to the formation of pathologic products, with a resultant clinical symptomatology that makes the case diagnosable before the disease has extended far from the primary focus. Rarely indeed does nature succeed in limiting the disease to such primary foci. If left undisturbed the bacilli spread to structures lying along the course of and in connection with the excretory duct of the organ primarily involved, the ducts themselves becoming, in the majority of instances, likewise diseased. Unfortunately, the major symptomatology of urogenital tuberculosis is expressive of the extension processes rather than the development of the disease at the point of primary lodgment of the bacilli. Patients therefore, especially those with renal tuberculosis, seek assistance at a comparatively late stage of the disease.

Tuberculosis frequently appears simultaneously in the male genital and urinary systems. This multiplicity of organic involvement implies a marked susceptibility of these particular structures to the disease, a fact that must be taken into account in advising operation. A complicating infection of the epididymis, tending as it does to spread along and infect the adenexa of and structures adjacent to the spermatic duct, further adds to the seriousness of a given case of renal tuberculosis for the reason that a lower urinary complication, primarily dependent upon the renal condition, may be continued after nephrectomy by the ascension of the disease from the epididymis, or by a direct extension to the bladder from a diseased vesicle or prostate.

For this reason, it is truly axiomatic to say that the prognosis in tuberculosis of the urogenital system is favorable in direct ratio to the degree of limitation of the disease in the structures primarily involved.

The tubercle bacilli usually find primary lodgment in the glomeruli situated in that part of the renal cortex which is nearest the medulla. The disease may remain localized to this point for a considerable period of time; it may spread and involve the greater portion of the kidney in a rapidly destructive process, or it may, by virtue of the ascendancy of reparative processes, cause changes that result in total destruction of the renal parenchyma, notwithstanding which the disease remains limited to the kidney. Probably the universal surgical dictum, which demands nephrectomy in practically all cases of unilateral renal tuberculosis, is founded on that degree of existing ignorance which prevents differentiation between the small number of cases which would recover spontaneously from that far greater group in which from the beginning the disease is destined to progress to the ultimate death of the individual.

Tuberculosis of the kidney is peculiarly prone to remain localized to the upper urinary tract for a considerable period of time, but finally to spread to the bladder, and if left undisturbed, to attack the opposite kidney. In a series of 459 post-mortem subjects with the caseo-cavernous form of renal tuberculosis, Kelly and Burnam ("Diseases of the Kidney, Ureters and Bladder," 1914) found the disease localized to one kidney in 253 ($55\frac{1}{10}$ per cent.) instances. Furthermore, Kelly has confirmed Israel's statement that in only nine per cent. of patients who come for examination with tuberculosis of the kidneys is the disease bilateral. Complete limitation of the disease to the kidney in cases which come for operation, is comparatively rare, according to Kelly—34 per cent., an estimation, which so far as the male is concerned, seems to us most generous. In the great majority of males, the primary cystoscopic examination demonstrates involvement of the ureter, together with that portion of the bladder wall immediately adjacent to its orifice. Bladder involvement with ulcerations at points distant and separate from the ulceration surrounding the meatus of the ureter, signifies unusual susceptibility of the bladder mucosa to tuberculous infection and has grave prognostic meaning. This is well illustrated by a series of sixty-four cases of unilateral renal tuberculosis, complicated by vesicle involvement and reported by Kelly of which only nineteen remained well after operation. Contrast this with 100 per cent. of cures in a series of thirty-four cases reported by the same writer, in which the disease was limited to the kidney. Therefore, time reckoned on the destructive progress of the disease is of the greatest importance in devising treatment and estimating the prognosis.

Secondary deaths following nephrectomy for unilateral renal tuberculosis are due, in the majority of instances, to extension of the disease with ultimate involvement of the opposite kidney. In a not inconsiderable proportion of cases, the relief of bladder symptoms after operation is shortlived and life is little, if at all, prolonged. Grave doubts as to the propriety of operation accompany the postoperative observation of a

proportion of cases, and, notwithstanding the fact that nephrectomy in the treatment of unilateral renal tuberculosis has no worthy alternative, the fact remains that surgeons continue to ask themselves whether something more or something less could not have done, or left undone in a certain percentage of cases. We will attempt to illustrate by case reports, certain instances under which such self-questioning might arise.

Surgeons agree that unilateral renal tuberculosis calls for nephrectomy, but the disposal of the concomitantly diseased ureter is not governed by any universal rule of practice. To remove the ureter when it is unnecessary to do so, is probably less unfortunate than to leave it behind, when, as events subsequently prove, it should have been removed. Illustrative of this latter contingency is the case of:

Mrs. T., aged twenty-four years, an Italian woman, was admitted to the Methodist Episcopal Hospital of Philadelphia, in October, 1916, on the service of Dr. Wm. R. Nicholson. This patient had been suffering with the usual symptoms of urinary tuberculosis for a period of nine months. Pain in the left loin space was a prominent symptom. The left kidney was easily palpable and freely movable, but neither markedly enlarged nor tender. Tenderness, however, was elicited on deep pressure in the left inguinal region. A much thickened and tender left ureter was palpable per vagina. On October 5, 1916, a cystoscopic examination was made by Dr. Geo. Outerbridge, who reported his findings as follows: "Congestion and erosions in the region of the left ureter; cloudy fluid obtained per catheter from the left ureter in a rapid flow suggestive of pelvic retention. Normal urine obtained from the right kidney. Diagnosis: Infected left kidney, probably tuberculosis, with moderate dilatation of the renal pelvis."

The patient was then transferred to the surgical service of Dr. Jas. Baldwin, who asked me to make a cystoscopic examination. The findings confirmed the previous findings. Both kidneys were functionally active. Indigo-carmin, given intravenously, was eliminated from the right kidney in three minutes and from the left kidney in four and one-half minutes. The left ureteral pelvis was slightly dilated, its capacity being 15 c.c. The urine from the left kidney contained pus, that from the right kidney was normal. Sterile cultures were obtained from both specimens of urine. Guinea-pig inoculations were made with negative results and tubercle bacilli were searched for in the urine but none were found. On November 11, 1916, Doctor Baldwin (with whose permission the case is reported) removed the left kidney and the abdominal portion of the ureter. The latter was enlarged, soft and boggy, and evidently the seat of an active tuberculosis. The kidney was moderately enlarged and showed a general chronic miliary tuberculosis with beginning caseation and cavity formation. The pelvis of the ureter was moderately dilated and its walls were much thickened.

This patient had a long convalescence with the eventual formation of a chronic sinus, to cure which it became necessary to subsequently remove the remaining segment of the ureter.

This form of rather generalized chronic miliary tuberculosis of the kidney and ureter, which causes an enlargement of the kidney of moderate degree, and an enlargement, softness and boggyiness of the ureter, together with tuberculous periureteritis, is an indication for total removal of the ureter, or at least its removal to a point well below the limits of its grossly apparent involvement. This type of ureteral infection is probably not a descending one in all instances, but the involvement of the ureter may occur concomitantly with that of the kidney and, like the infection of the latter, may be blood-borne. Whether the total removal of a tuberculous ureter of this variety should be done as a primary procedure, or whether the proximal end should be attached to the incisional margin, as advised by Mayo for certain other types of diseased ureters, with secondary removal if necessity demands, is perhaps an open question.

It is reported from the Mayo Clinic that less than five per cent. of the ureters in tuberculosis of the kidney require removal. "These," Wm. H. Mayo (*Surgery, Gynecology and Obstetrics*, 1912, p. 93) says, "are usually cases in which a stricture exists in the lower portion of the ureter, close to the bladder, so that there is more or less retention on that side." In a second group of cases, comprising those in which the diseased kidney is functionally active and where there is a mixed infection present, sewing the stump of the ureter to the lower end of the incision is employed as an alternative measure to its complete primary removal. Rarely, in the Mayos' experience, is it necessary to remove the remaining segment of the ureter secondarily to cure a persistent sinus. The enlarged pipe-stem ureter whose walls have undergone what may conveniently be called eccentric hypertrophy, is generally left undisturbed in the absence of infection. Ureters of this type, when possessed of an enlarged lumen which is in free communication with the bladder through a so-called golf-hole ureteral meatus, should be removed completely. Certainly is this true in the presence of secondary infection. If the uretero-vesical valve is functionally normal, these rigid ureters may probably be retained with safety in the absence of a complicating secondary infection.

The several gross types of tuberculous kidneys develop independently of the physical state of the ureter. Nevertheless, the pre-operative determination that the kidney is non-functioning and its ureter closed as the result of inflammatory changes, will comfort the operator in those cases where subcapsular nephrectomy becomes necessary. Under these circumstances the ureter need not be disturbed. In cases complicated by large perirenal collections, the ureter should probably not be disturbed if one can be reasonably sure that it is undergoing or has completed a process of inflammatory obliteration. From the study of patients whose

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convalescence after nephrectomy for unilateral renal tuberculosis has been complicated by persistent sinus formation, or continued bladder infection due to retained segments of the ureter, and from the published opinions of various surgeons, we may classify the cases in which total removal of the ureter is indicated as follows:

(1) Those cases in which the ureter is strictured below, dilated above and secondarily infected.

(2) Those cases in which the ureter is dilated, infected and in free communication with the bladder cavity.

(3) Cases in which the ureter is enlarged, soft and diffusely involved in a subacute miliary tuberculous process. The complete removal of ureters otherwise involved pathologically is, with certain exceptions, to err on the side of doing unnecessary work. With the exceptions just given, which comprise a surprisingly small number of the total, the ureter should either not be disturbed at all, or only such part of it should be removed as can conveniently be reached through the ordinary nephrectomy wound.

Some unfortunate mistakes are made in connection with unilateral renal tuberculosis, through a failure to recognize the renal lesion in the presence of a complicating genital infection. This occurred in the case of:

J. G., aged twenty-seven years, was referred to the writer from Atlantic City in April, 1916, suffering with acute inflammation of the left epididymis. The gonococcus was found in urethral smears and in pus removed from the epididymis. The epididymotomy wound failed to heal and he returned seven months after the operation with a scrotal sinus. His urine was found at this time to be laden with pus. The epididymis on the operated side was found to be indurated and nodular throughout. The prostate gland and seminal vesicles were not grossly diseased. Careful questioning disclosed an ancient history of cloudy urine and bladder symptoms, antedating the beginning of the ureteritis and epididymitis. Cystoscopic examination demonstrated the presence of an infected and functionless left kidney and a normal right kidney. The normal kidney excreted indigo-carmin (intravenous) in seven minutes, while its diseased fellow failed to excrete any of the dye during a half-hour period. The total phenol-sulphone-phthalein output (intramuscular) was 27 per cent. All attempts to recover the tubercle bacilli from the urine failed. The X-ray showed a large shadow in the region of the left kidney. The patient refused operation at this time, but I have since learned that the left kidney was later removed and that the patient has now completely recovered.

A very early tuberculosis of one kidney may be overlooked in the presence of a more obvious non-tuberculous lesion of its fellow of the opposite side. This apparently is what occurred in the case about to be described. This patient, however, may or may not have had an early tuberculosis at the time of the first operation. Certainly the examination

failed to disclose any real evidence of the presence of tuberculosis, but it is entirely probable that the operation of nephropexy, which was done for ptosis of the opposite kidney, threw an additional strain on the supposedly healthy left kidney, which latter was, in reality, harboring a latent focus of tuberculosis. This case is reported with the kind permission of Dr. John B. Deaver and Dr. Wm. H. MacKinney:

H. H., aged twenty-six years, was admitted at the Lankenau Hospital in September, 1917, suffering with pain in the left lumbar region. The initial attack of renal pain came eight years before the beginning of her present trouble and was followed by great frequency of urination. She recovered promptly, however, and was perfectly well for six years when an attack similar to the initial one began. She again recovered promptly and was well until a short while before her first admission to the hospital. Physical examination at this time revealed nothing remotely suggestive of renal tuberculosis, but the right kidney was ptosed and movable. Nephropexy was done and the appendix was removed. She recovered promptly and was entirely well for a period of two months, when intermittent hæmaturia made its appearance. Eight months from the time of the first operation, she was readmitted to the hospital. A cystoscopic examination was made (Doctor MacKinney) which disclosed the presence of ulcerations around the orifices of both ureters and on the trigone. Functional studies of the kidneys were made and showed markedly diminished secretory power on the part of the left kidney. Urine obtained from the left kidney was found to contain a great deal of pus. The right kidney was functionally normal. The left kidney was exposed and its surface was found studded with tubercles. It was removed, together with the abdominal portion of the ureter, and the patient made an uneventful recovery.

Primary tuberculosis of the bladder is undoubtedly a clinical entity but the condition is an extremely rare one. Not infrequently, a primary renal lesion is so limited in extent and so few and indefinite are the signs and symptoms to which it gives rise, that its presence is undeterminable in the study of an obvious vesical tuberculosis to which it has given rise. In the case about to be described, the pre-operative cystoscopic studies by Doctor MacKinney suggested the presence of primary renal tuberculosis. At operation, Doctor Deaver (with whose permission the case is reported) found nothing abnormal in the surface appearance of the kidney. He then incised it and the cut surface was also normal in appearance. The wound in the kidney was then sutured and the organ replaced. The patient made a rapid and complete operative recovery, but no record has been obtained of the subsequent course of the disease.

Mrs. S. P., negress, aged thirty years, was admitted to the Lankenau Hospital on October 22, 1917, complaining of burning on

urination and pain in the upper abdomen and back. The cystoscopic examination disclosed the presence of ulcerations typical of tuberculosis. Both ureters were catheterized and found to be unobstructed. Indigo-carmin was eliminated from the right kidney in seven minutes, but none came from the left side in fifteen minutes. The left kidney was exposed, incised, but nothing abnormal could be found. It was then sutured and replaced and the wound closed.

The foregoing case is either an example of that extremely rare condition, namely, primary vesical tuberculosis, or what is probably quite as likely, an instance of localized renal tuberculosis the site of which escaped detection, notwithstanding the thorough search made for it. This latter is the viewpoint held by Doctor Deaver, who operated upon the case. The diminished renal function in this case, as was indicated by the slow and incomplete elimination of indigo-carmin, suggests the kidney as the primary focus of disease in this instance, or at least an involvement of the kidney in the diseased process. We believe personally, that minor degrees of lost renal function can best be determined through differential studies of the percentage output of phenol-phthalein, although the evidence furnished by the indigo-carmin test in the case just quoted, seemed most conclusive. In cases where the shadow of a doubt exists regarding the state of renal function, it would seem the part of wisdom to employ both of these valuable adjuncts to diagnosis. We have lately made the interesting observation that the excretion of indigo-carmin is sometimes greatly delayed under ether anæsthesia, thus in a recent case of tuberculosis of the left kidney and bladder (referred by Dr. Jas. Talley) the excretion of indigo-carmin from a normal right kidney was delayed for a period of twenty-nine minutes, the patient being under ether anæsthesia; this same kidney excreted 40 per cent. of phthalein (intravenous) in a half-hour period and 65 per cent. of phthalein (intramuscular) during a period of two hours. During the first twenty-four hours, after removal of the tuberculous left kidney, the remaining kidney secreted thirty-four ounces of urine. To have depended solely on the indigo-carmin tests in this particular case, would have led us far astray of the true conditions present. To determine quantitatively the secretory activities of the kidney it is sometimes necessary, not only to employ the several functional tests, but to repeat these tests until the normal average of functional power of the kidneys can be ascertained.

FIBROMA OF THE TESTICLE

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MALIGNANT tumors and teratomata of the testis are not particularly uncommon; but benign tumors, especially fibromata, are indeed rare findings. The various text-books on pathology dismiss the subject by stating that it may occur, but is exceedingly uncommon. The writer may be justified, therefore, in presenting the following report and discussion.

Mr. E. P. (History No. 12833), thirty-three years of age. Admitted to Mt. Carmel Hospital July 17, 1918, service of Dr. C. S. Hamilton and Dr. E. C. Brock, on account of a painful swelling of left testis.

Present Illness.—On June 5 (12 days previous to admission) the patient fell on a bar in such manner that the left testicle was pinched. The organ gradually increased in size, up to the time of admission. The swelling was accompanied by pain, and the patient had to give up his occupational activities.

Personal History.—Patient had mumps about fifteen years ago, and both testes were slightly involved. The right testis returned to normal size in due time, but the swelling on the left side has persisted ever since. Patient had "black" measles eight years ago, with resultant "weakness" of eyes. General health has been good. When admitted the left testis was greatly enlarged, measuring about 12 by 6 by 6 cm. The mass is very firm, and feels roughened or corrugated. It does not transmit light. The enlarged testis was removed by Dr. E. C. Brock. Examination of the mass removed showed a neoplasm associated with the tunica, also a small nodule separate. The patient made an uninterrupted recovery, and left the hospital ten days later.

Report of Pathologist.—Gross examinations: The mass measures 12 by 6 by 6 cm. It is very firm and covered with fibrous adhesions. On section one finds near the middle of the mass, the testicle proper, slightly larger than normal, measuring 6 by 3 by 2 cm. (Fig. 1 a). About four-fifths of the surface of the testicle is smooth and free. A narrow zone on the anterior surface, about 4 mm. wide, and running the entire length of the testicle marks the attachment of a fibrous growth (Fig. 1 x). This new growth extends around the testicle so as to completely surround the organ. The least thickness of the neoplasm is found at the line of origin, and measures 4 mm. From this point the tumor grows progressively larger until it reaches a maximum thickness of 4 cm. on the other side of the testis. The new growth is completely encapsulated. On the posterior side of the testis is the attachment of another firm, fibrous, encapsulated nodule 12 mm. in diameter. This nodule appears to have developed entirely independent of the larger growth. The points of origin of the neoplasms appear to be in the tunica albuginea, which is



FIG. 1.—Gross appearance.

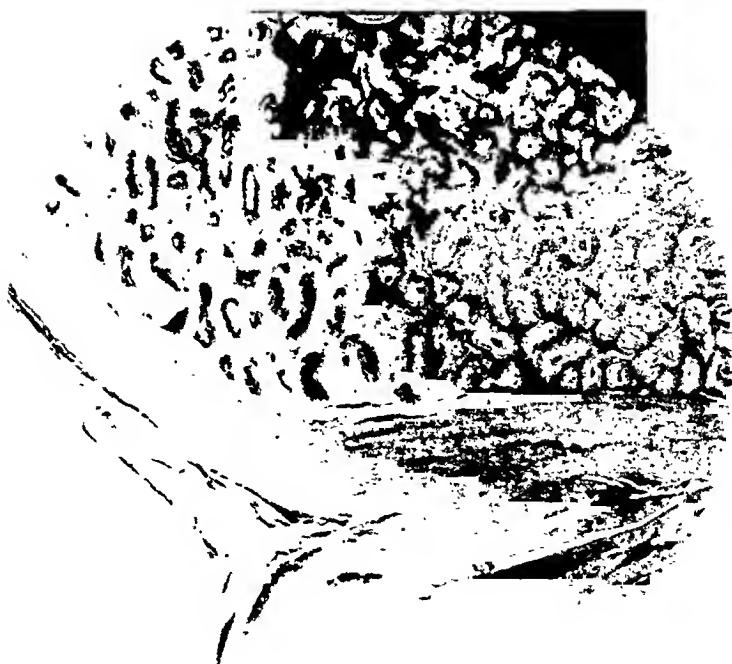


FIG. 2.—Microphotograph showing origin of tumor at X.



FIG. 3.—Microphotograph showing richly cellular areas.



FIG. 4.—Microphotograph showing less cellular areas.

FIBROMA OF THE TESTICLE

sharply demarcated from, yet densely adherent to, the tumor. There is no evidence of calcification or cyst formation.

Histopathology.—The parenchymatous tissue of the testis is of normal appearance. Within the tubules one finds the usual cells, etc. The portion of the tunica albuginea that is not in contact with the new growth presents a normal appearance. One finds the usual connective tissues and capillaries. The area of the tunica in contact with the neoplasm presents a different appearance (Fig. 2 x). Strands of fibrous connective tissue of the tunica have grown outward, beyond the usual boundary. Productive proliferation and persistent growth have caused the formation of the tumor mass. The tumor mass is composed of fibrous tissue, which contains many proliferating fibroblasts. Blood capillaries are unevenly distributed throughout the tumor. Round cell infiltration is not found. Fibroglia fibrils are present, but there is a great excess of collagen fibrils. Some areas are richly cellular (Fig. 3), the nuclei staining deeply with hematoxylin. Mitotic figures are found, and the general appearance is slightly suggestive of sarcoma. Other areas are less cellular (Fig. 4), and contain more collagen; the fibroblasts are older; and there are fewer mitotic figures. There is nothing indicative of teratomatous origin.

Diagnosis.—Fibroma of the testis.

Discussion.—There is presented here a fibroma which has developed from the tunica albuginea. The most marked feature of the tumor is its large size and the great rapidity of its growth. According to the history, this hard mass had formed in twelve days. That such a firm fibrous growth could occur within two weeks seems highly improbable, yet how else may we explain its appearance? As a result of mumps, fifteen years previous, the testicle was swollen and had remained so ever since. Was this enlargement the true beginning of the fibroma, or did it contribute, in some obscure way, to the later formation of the neoplasm? Or was the tumor the result of the traumatic injury of recent date? We do know, however, that the major portion of the growth was actually produced within the twelve days.

Although the neoplasm completely surrounded the testis, and *produced pain*, yet there is no evidence of pressure atrophy of the organ. Due to these puzzling factors the clinical diagnosis was withheld.

A NEW OPERATING COMPOSITE CYSTO-URETHROSCOPE

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OWING to many difficulties to be overcome in urethroscopy, I had, in 1911, devised a urethroscope operated by air distention and provided with a megascope, which turned on hinges from side to side, thus allowing space for intra-urethral manipulations. The picture obtained by its use was clear, well defined and magnificently enlarged. Its outstanding features were particularly noticeable in the examination of the anterior and membranous urethra, where a concentric view is desirable. Its utility was no less apparent in the prostatic urethra and at the internal

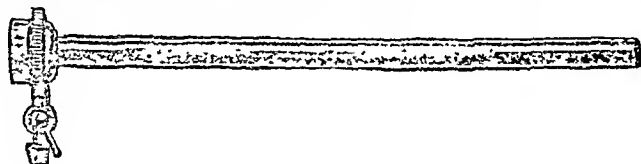


FIG. 1.—Endoscopic tube, straight end.

vesical sphincter. The visual and operative field is much larger in the prostatic urethra when viewed through this than through any other instrument.

In the last two or three years, I used in some cases the same instrument, with water as a distending medium, but without any magnifying system. Then, after acquainting myself with the work of Luys, in which he speaks of dilating and catheterizing the ejaculatory ducts for diseases of the seminal vesicles, I set out to construct an instrument, a modifica-



FIG. 2.—Endoscopic tube, end opened on 45° angle.

tion of my old model, by means of which it would be possible to accomplish it without great difficulty and without undue traumatism of the tissues.

When constructing the instrument, I bore the following principles in mind: First, to obtain a concentric view of the anterior and posterior urethra; particularly, is this important in incipient prostatic enlargement, which can but with great difficulty be made out with the average rec-

COMPOSITE CYSTO-URETHROSCOPE

tangular cystoscope; whereas, when looked at directly from the posterior urethra, the entire sphincter stands out in bold relief, and can be studied in relation with the prostate, and the distance of the colliculus from the sphincter; secondly, when the tissues in the posterior urethra are bleeding, clots of blood usually adhere to the telescope and lamp, thus obstructing the view, or causing a false interpretation of the picture, an annoyance which can be cleared up only by removing the telescope and washing it thoroughly; and while doing this, one often dislodges the instrument, and

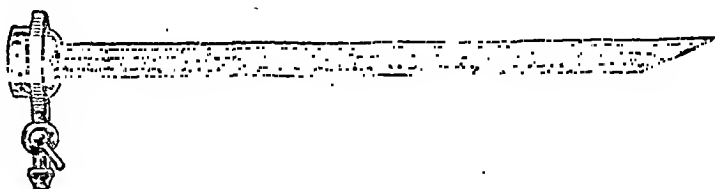


FIG. 3.—Endoscopic tube.

loses the field under observation. Then, again, in the membranous urethra it is of advantage to get a concentric field, for with the prismatic type of urethrosopes, the lens being so near the tissues which are less dilatable than either the prostatic or anterior urethra, it is, in a considerable number of cases, impossible to get a true picture of the lesion. It is needless to say, that, in the anterior urethra, not only is a concentric view desirable for an accurate diagnosis, but that an instrument giving



FIG. 4.—Window for operative work.



FIG. 5.—Window for water dilatation with lens.

such a view is easier of manipulation, both for inspection and treatment. Another important point to bear in mind is that, when the tissues are kept on a stretch by a fluid medium, particularly when viewed through a prismatic system of lenses, they are paler and are accompanied by a certain amount of distortion of the image, thus endangering a false interpretation, in addition to having a less illuminated field owing to a considerable amount of light absorbed by the lens system. It is obvious,

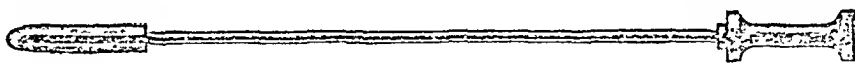


FIG. 6.—Straight obturator.

then, that urethroscope which can be used with water and air at the same time, thus comparing the differences in appearance under air and fluid, will be more serviceable both for an accurate diagnosis and for appropriate treatment.

No less important is the disinfection of intravesical and intra-urethral instruments by heat rather than by chemical antiseptics, especially when a number of patients have to be examined in succession.

In compliance with the foregoing principles, I had the Kny-Sheerer Corporation construct a urethroscope which I shall describe in detail. It consists of three tubes, each 17 cm. long and 25 mm. in circumference; one straight tube with a straight obturator for the anterior urethra; one straight tube, the distal end of which is cut off at an angle of 45° , provided with a special obturator, which may be bent or straightened at the

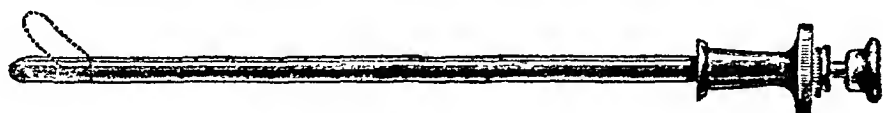


FIG. 7.—Posterior obturator.

distal end by pressing or relaxing the proximal end of the obturator; and, lastly, a straight tube, whose distal end is cut off at an angle of 30° , used for the posterior urethra, and giving a larger operating field. The proximal end of the tubes is provided with stopcocks for irrigation and air distention. It is, furthermore, provided with two light carriers, one of which is used for inspection and topical applications and other operative



FIG. 8.—Light carrier with double end ground fitting for endoscope.

procedures in the urethra and the bladder; the other light carrier is combined with a deflector, having one catheter channel for the introduction of No. 5 bougies and catheters to be used in connection with utricle, ejaculatory ducts and ureters. The outstanding feature of this deflector is that the farther end does not come in contact with the verumontanum or any of the other tissues, thus sparing them from injury and its concomi-



FIG. 9.—Attachment for catheterization with lens, light carrier and lever operating catheter guiding fingers.

tant annoyances, and facilitating the introduction of bougies into the utricle, ejaculatory ducts and follicles, a manoeuvre which I tried repeatedly with the indirect catheterizing and direct vision cystoscope, with little or no success, due to the fact that the field of operation in the urethra is limited to such an extent that when the deflector of the ordinary cystoscope is used, the distal end of it coming in contact with the tissues, causes so much bleeding as to obscure the field of vision; and in case of

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the colliculus, pushes it out of the way, and flattens it to such a degree that operation is impossible; while with the direct vision cystoscope the catheter is lost in space.

The magnifying system consists of two sets of observation lenses, used for air and fluid, respectively. They are fastened, at will, to the proximal end of the light carrier, which facilitates the interchangeability of the water and air lenses, and thus makes it feasible to change from fluid to air media, without disturbing the instrument or losing the field under inspection. Next come two operating windows for air and fluid respectively. They are provided with perforated hoods, which can be tightened or relaxed, and serve for the introduction of various instru-

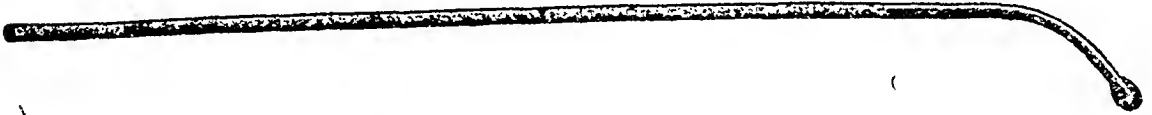


FIG. 10.—Tube for aspiration and bulb.

ments through them into the urethra and the bladder. The lens for the deflector is permanently fixed to it, it being used exclusively with water medium, for the reason that virulent germs may be prevented from being carried into the ejaculatory ducts, an accident which might frequently happen if air instead of fluid were used; whereas, if a fairly strong antiseptic solution, such as oxycyanide of mercury 1:5000, a solution which I used exclusively in the last eight years in all my cysto-urethroscopic work, is used, such accidents may then, in the large majority of cases, be forestalled.

The following accessories are used with this instrument: An aspirator with a bulb, for removing fluid from the urethra; a cannula, fitting

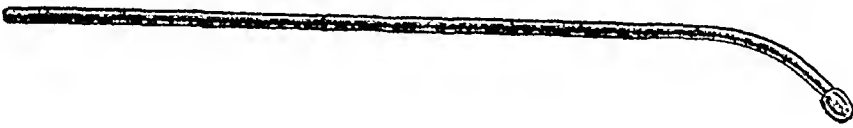


FIG. 11.—Tube for guiding filiforms.

snugly into the operating window, for the introduction of flexible instruments into the urethra, such as bougies, catheters and filiforms; one universal handle for detachable knives, curettes and cotton carriers; one pair of alligator forceps; one snare; one cautery; one instillator with syringe; one fulguration handle. In the near future I hope to add an aspirating attachment for evacuation of stone fragments after lithotripsy.

Modus Operandi.—The urethroscope should, before use, be boiled; while the light carrier or deflector be sterilized in pure carbolic acid and rinsed off in alcohol. It is a great advantage to have a regular cystoscopic table with either Bierhoff's or Young's legholders, a table which can be raised or lowered without disturbing the patient; for it often, in the course of the examination, becomes necessary to change the position of the patient. The legholders should be so adjusted as to bring the knees of the

patient above a higher level than his head, while the table is raised about 30 to 40 degrees from the horizontal plane, in order to give the patient a slightly exaggerated lithotomy position.

The instrument table with all the instruments arranged is placed to the right of the operator; the source of light, whether from the street current or a hand battery, together with the irrigator, should for the convenience of the operator be placed to his right. The long rubber tube, conveying the solution to the urethroscope, may be supported by the patient's legs. A cut-off, to control the influx of the solution, is

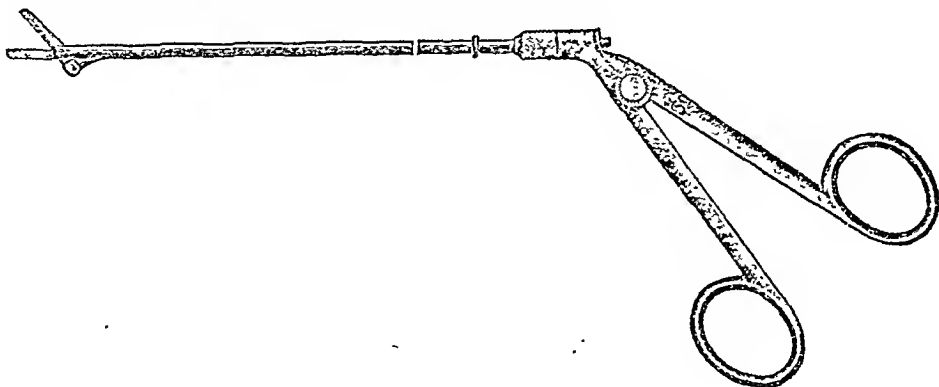


FIG. 12.—Scissors.

necessary, but let no reliance be placed on a makeshift. The Esmarch cut-off is the best to my knowledge, and the one I used with a great deal of satisfaction. There are others, which are not so easy to handle.

Assuming the patient is, for the first time, to be examined, enough of his clothing be removed to enable him to adopt a lithotomy position, with his knees well supported, the irrigator having previously been filled with 1:5000 oxycyanide solution, and the rubber tubing being supported by the patient's left leg. The proper tube for the posterior urethra, preferably, the one from which a smaller wedge has been removed, with the beaked obturator, is introduced into the bladder containing about three ounces

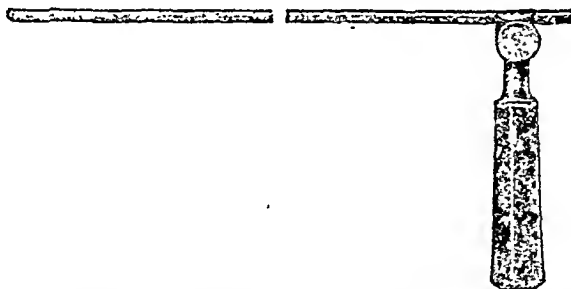


FIG. 13.—Tube for catheterization and for mounting operative instruments.

of urine. If the bladder has been completely emptied, then three ounces of the solution should be injected into it prior to the introduction of the instrument. This applies to all other hollow instruments used for the bladder, as well. The reason is simple: When a hollow tube with an obturator is introduced into the hollow viscus, whose walls are collapsed and assume the shape of the letter Y, the trigone with the base of the bladder representing one limb, while the roof representing the other, and both converging to the internal sphincter, are sucked into the opening of the tube, when the obturator is removed. This causes a circular area of hyperæmia, which resembles a punched-out ulcer of the bladder, and may, by the unwary, be readily mistaken for one. This

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accounts for many reported cases of ulcer of the bladder. There is no actual loss of substance, and it is but of an evanescent nature, the circulation being restored in a short while.

The proximal end of the obturator being held firmly between the thumb, index and middle fingers, the instrument is allowed to slide in gradually past the sphincter, the pressure from the proximal end of the obturator being released, when the obturator straightens out, becomes disengaged and easily dislodged from the urethroscope: it is then withdrawn. The examining lightcarrier is now attached to the urethroscopic tube, and the irrigating tube joined to the stopcock. The observation window is then fitted snugly to the urethroscope, the lamp connected with the electric current, and the water slowly turned on. As the water flows in, air bubbles are seen rising to the surface of the lens, partially obstructing the view. The air which accumulates



FIG. 14.—Curette.



FIG. 15.—Urotomy knife.

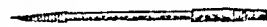


FIG. 16.—Cotton carrier.

on the under surface of the lens is allowed to escape by gently lifting the lens off the urethroscope, while the water continues to flow into the tube; then, the lens is reconnected with the urethroscope, when a perfectly lighted and clearly defined image appears at the distal end of the tube. As soon as the picture is clear, the current of water may temporarily be turned off. A systematic examination is now begun.

In order to obtain a good view of the trigone and the ureters, only about two or three ounces of fluid are required. They can be seen to the best advantage by lowering the table with the left hand of the operator to a horizontal position. To examine the other parts of the bladder, more distention is necessary, which can best be determined by experience. To get a good view of the roof of the bladder, the table should again be raised from the horizontal plane, and thus segment after segment be examined until the sphincter is reached. When in the course of the examination a little

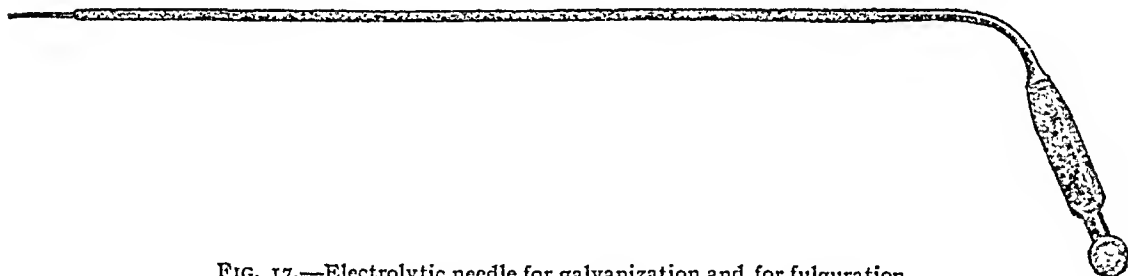


FIG. 17.—Electrolytic needle for galvanization and for fulguration.

film collects at the distal end of the tube, the water is turned on, a few c.c. of which are sufficient to clear the field. The posterior bladder wall, which is rather inaccessible to the usual indirect vision cystoscope, can be plainly made out by this instrument. The sphincter can best be seen by raising the table, and by gradually withdrawing the urethroscope into the posterior urethra, when the whole circular outline of it can be made out. This is of particular interest in connection with beginning prostatic adenoma.

By withdrawing the tube still further, the entire prostatic, membranous and anterior urethra is examined in turn. When in the course of urethroscopic examination the field gets blurred, the stopcock is again opened, and the solution is allowed to flow in, to wash out any secretions that obstruct the view.

When the prostatic urethra is inspected by this instrument, it may be seen in its entirety at one glance. All the walls are distended, the

prostatic fossæ are flattened out, the prostatic follicles are easily made out, and in many instances pus can be seen oozing out from them. The longitudinal folds, a continuation of similar folds of the uvula of the bladder, are plainly seen. Particular attention should be paid to them, since very often infected follicles together with fine thread-like polypi, are situated between them. The verumontanum stands out prominently in the floor of the urethra, and it may be seen in its entirety or in part, according to the angle at which the instrument is manipulated. The utricle is nearly always seen at or near the summit. Its outline should be carefully studied. It is often inflamed, having angry infiltrated edges and dis-

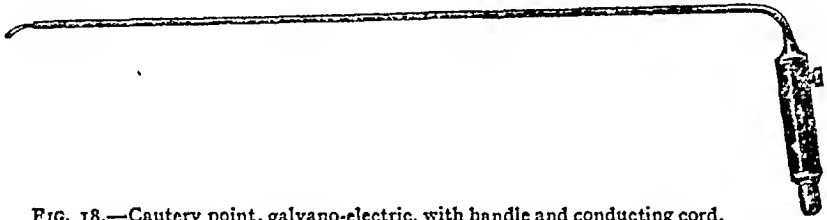


FIG. 18.—Cautery point, galvano-electric, with handle and conducting cord.

charging pus. In the average case, the ejaculatory ducts should be looked for at the extreme edge of the colliculus seminalis, on a plane with the utricle, though frequently they are located in the immediate vicinity, on either side of the utricle. When the colliculus is highly turgescient, then the central part of it bulges out and pushes the ducts to the extreme edge, so that they may be lost in the intense boggiessness of the tissues. They may then be temporarily lost from sight to reappear after the subsidence of the tumefaction of the tissues. When one looks for them in the verumontanum of the cadaver, they are, in the large majority of cases, seen on either side of the utricle, due to the collapsed

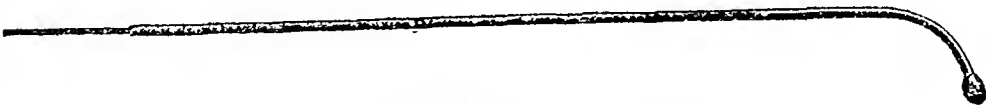


FIG. 19.—Tube for application of medicaments of silver.

state of the tissues; and this is the usual location assigned to them by the various text-books of anatomy. When looking for them with this instrument, it is advisable to manipulate the urethroscope at different angles. After a few trials one becomes proficient in locating them.

As to the therapeutic value that may accrue therefrom, time alone will decide. I have introduced filiforms and No. 3 bougies into them in from 60 to 80 cases, practically all private patients, and for that reason I have been chary in aspirating and injecting the ducts, as I hope some day to do. From a little unpleasant experience that I had from using a filiform bougie for the ducts, though it led to no untoward effects, I



FIG. 21.—Showing urethral cavity, ejaculatory ducts and extremely large utricle.



FIG. 22.—Showing roof of urethra, lateral walls, utricle and ejaculatory ducts.



FIG. 23.—Showing normal ureter as seen by the cysto-urethroscope.



FIG. 24.—Showing normal base of bladder.

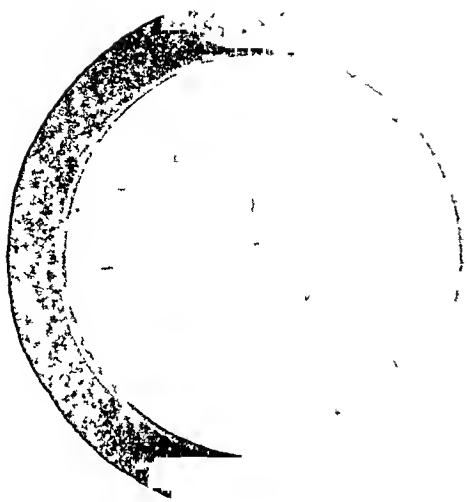


FIG 25 —Showing polyp on summit of Verumontana



FIG 26 —Showing cystic distention of glands in post-urethra.



FIG 27 —Showing sphincter—cystic glands around it



FIG. 28 —Showing membranous urethra polyp on floor



FIG. 29.—Showing humpbacked Verumontana.

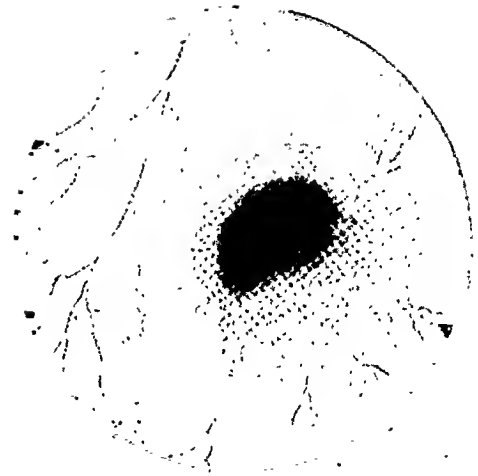


FIG. 30.—Showing diverticulum of posterior wall of bladder with congested edges, due to a stone lodged in there but passed two days before the examination.

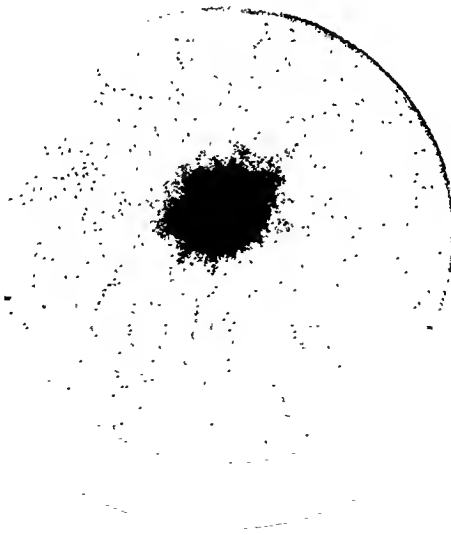


FIG. 31.—Showing normal membranous urethra.

should advise against its use, but to depend exclusively on the Nos. 3 or 4 silk bougies.

The case in question is a young sexual neurasthenic, who throve on urethral instrumentation. Accordingly, I introduced a filiform for a distance of one inch and a quarter into one of his ejaculatory ducts, when I called a truce and wanted to withdraw it. I suddenly felt a jerk, as one feels when trying to remove a sound from a tight stricture; I redoubled my efforts to extract it, when suddenly I felt a snap, and a part broke off. Fortunately that fragment was seen protruding from the opening, and I had no difficulty in extracting it with the aid of forceps. Since then I gave up the use of filiforms for that purpose, but I use silk bougies instead.

One practical lesson I learned from this experience, namely, that the ejaculatory ducts have a strongly developed circularly arranged muscular coat, which contracts spasmodically. It is not at all unlikely when

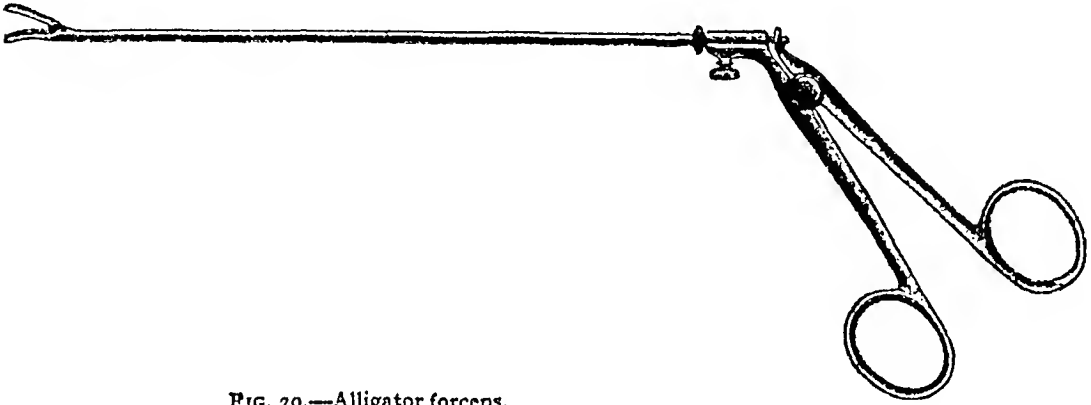


FIG. 20.—Alligator forceps.

considering the oblique route they take in the prostatic substance, and their configuration, being dilated above, near the seminal vesicles, and tapering in their descent towards the urethra, that by the contraction of their circular fibres, they assume a sphincteric action and prevent the leakage of the seminal secretions. It may, furthermore, explain the spasmodically occurring colicky pains in the perineum, reflected in various directions, as being due to distended and inflamed vesicles, the contents of which are under a greater pressure than normally, and in trying to escape into the urethra are impeded from so doing by powerful contractions of the ducts.

Twice I have seen an epididymitis develop, and in both cases only after repeated dilatations of the duct.

After the prostatic urethra has been gone over carefully, all the other parts of the urethra should, by gradually withdrawing the instrument, be thoroughly examined.

When in the course of an examination, one wishes to make direct applications to the urethra, he can easily do so by aspirating the fluid from the urethra through a special aspirator designed for that purpose;

under these conditions, the air window should be substituted for the other, in order to get a magnified vision.

After one familiarizes himself with the examining constituents of this instrument, he can easily make use of all the operative attachments, namely, the deflector and the perforated windows with their accessories, being guided by the principles as heretofore outlined.

This urethroscope is also available for the use of air as advocated by Luys, and Kelly, or by forcible distention with air through an air bulb.

The Kelly method is applicable in women with short urethræ, in whom the introduction of instruments is very simple in the knee-chest position.

Luys, on the other hand, treating mostly males, advises an extreme Trendelenburg position for his patients, being practically impossible to introduce an instrument into the male urethra in the genu-pectoral position. Only in exceptional cases does he resort to the knee-chest posture in the male, but he first introduces the instrument in the ordinary position, then he very cautiously turns him over in the knee-chest position.

When one finds it difficult to get sufficient air distention of the bladder by either of the two methods, then forcible inflation by means of a rubber bulb may be resorted to.

To sum up: This composite cysto-urethroscope has a wide field of application, both in the bladder and the urethra of the male and the female. Lesions in the posterior wall of the bladder are more easily accessible to this than to the rectangular vision cystoscope. Its simplicity of construction together with its ease of manipulation lends itself to various operative procedures in the bladder and the urethra. The deflector makes it possible to reach any part in the urethra without injury to the tissues. It is especially applicable for fulguration of tumors, inflamed areas in the urethra, and destruction of glands and cysts. The cautery may be used for the destruction of median prostatic bars, using air instead of fluid for a distending medium.

I append a few illustrations of normal and abnormal conditions of the urethra and the bladder as seen through this instrument and sketched by an artist at the examination table.

DUPUYTREN'S CONTRACTURE, WITH A DESCRIPTION OF A METHOD OF OPERATION

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THE treatment of Dupuytren's contracture has long been tedious, difficult, and often unsuccessful. Even when temporary restoration of the hand has been secured, relapse has been common.

The author's experience, limited though it has been, in plastic surgery of the hand and forearm, has proved to him the great value of the free fat transplant in preventing adhesions after the excision of scar tissue and after extensive dissections. It has also demonstrated the advantage of making incisions along the line of the natural creases of the hand and fingers in order to secure healing of the wound without danger of subsequent keloid growth, contracture, and adhesion of the scar to underlying structures.¹

This led the author to employ the following method of operation for Dupuytren's contracture:

(1) Under general anæsthesia, without the use of a tourniquet, a transverse incision is made along the distal palmar crease. Through this incision alone a careful dissection is made of the entire palmar fascia to or beyond the crease at the base of the thenar eminence, as far towards the base of the palm as is necessary, and to the web of the fingers. The skin is adherent to the fascia, and the dissection must be made carefully to avoid button-holing the skin. With proper retraction as the dissection proceeds it is found that the entire fascia can be exposed and freed within the limits mentioned.

(2) The contracted fascia is then excised without injury to the underlying tendons, vessels, and nerves. The tendons do not require lengthening as they do not participate in the contracture.

If contracted fascia is present on the palmar aspect of the proximal phalanges, it may be excised through transverse incisions along the crease at the base of each finger involved.

If now it is found that the proximal interphalangeal joint can not be extended, or that it can be extended and flexed again only with a snap, the head of the first phalanx must be excised through a transverse dorsal incision over the joint. Professor J. Hutchinson lays great stress upon the necessity of this procedure in long-standing cases. This is, of course, a familiar procedure to surgeons who are accustomed to operate on

¹ Plastic Reconstructive Surgery of the Hand and Forearm. ANNALS OF SURGERY, July, 1918.

hammer-toes or on fingers long held flexed by other causes than Dupuytren's contracture.

(3) A small free fat transplant from the thigh is inserted smoothly beneath the palmar skin. It will lie in position without sutures. It is placed here to prevent subsequent adhesion of the skin to the tendons and to reconstruct the normal softness and plumpness of the palm of the hand. The incision is closed with a few interrupted sutures of No. 0 chromicized catgut. The hand is dressed on a well padded splint for a week. Slight serous discharge may occur for a short time, which is probably due to some dissolution of the fat transplant. Infection from the outside may be prevented by the use of dichloramine-T on the wound at the daily dressings. Great care should be taken, of course, at the time of operation to avoid infection.

The following case will illustrate this method of operation:

CASE I.—J. C., a tool-cutter, was seen at the Episcopal Hospital on July 29, 1918. About the middle of June his right hand was injured in a machine. The palm was contused, but the skin was not broken. The injury was not sufficient to cause him to stop work. Thereafter he experienced soreness in the palm, particularly after working.

On examination there was present a marked thickening on the ulnar side which extended to the middle of the palm of the right hand. Active and passive extension of the little finger was limited to 160°. Massage was ordered.

On August 12 it was observed that the condition had spread since the first examination and that the little finger was flexed more acutely and that the ring finger was also partially contracted.

Later, on September 9, the contracture involved the palmar fascia as far as the base of the thenar eminence, and the contracture of the little and ring fingers was more marked.

Operation was performed on September 23, 1918, by the method described above. The entire palmar fascia was excised from its ulnar border to slightly beyond the crease at the base of the thenar eminence and from the base of the palm to the web of the fingers. It was unnecessary in this case to go beyond the web. A free fat transplant from the thigh was inserted beneath the skin, and the transverse incision was closed with a few interrupted chromicized catgut sutures. The hand was dressed on a palmar splint.

The wound healed, but ten days after the operation its outer portion broke down and discharged a small amount of serum for several weeks. No pus was present. It was dressed with dichloramine-T. Eventually the wound healed again, with a scar that is scarcely perceptible, with no induration in the palm or about the scar, and with normal motion of the finger.

The condition of the patient at the present time is as follows: The scar along the distal transverse crease can with difficulty be seen; the palm is soft and plump, but not unduly so, and the motion and function of the fingers are absolutely normal. The little finger

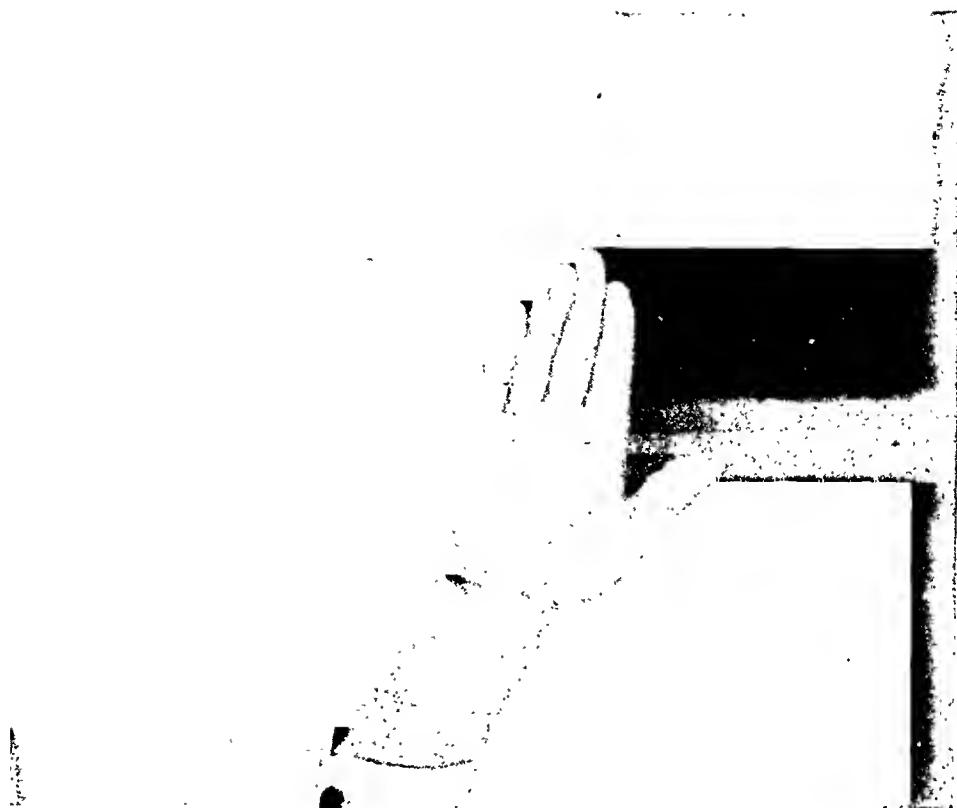


FIG. 1.—Hand of patient three months after operation, showing normal extension of fingers and absence of perceptible scar.

of his left hand has been amputated. A little over a year ago he developed a Dupuytren's contracture of his left hand for which he underwent seven operations in another hospital and eventually had the little finger amputated.

Dupuytren's contracture was described by Sir Astley Cooper, but it was first dissected by Dupuytren in 1831, who demonstrated that the condition is one of contracture of the palmar fascia alone without involvement of the flexor tendons. Sir Robert Jones defines it as a fibrositis of the palmar fascia not associated with any inflammation thickening of the skin.

Pathologically there is a thickening and contracture of the digital processes of the palmar fascia primarily and of the main body of the fascia secondarily. In extreme cases the interphalangeal joints may become partially dislocated. Microscopically the fascia is found to consist of fibrous bands with cellular infiltration characteristic of a plastic inflammation.

The palmar skin is puckered and usually is closely adherent to the fascia.

There have been two theories as to the etiology:

(1) That the contracture is due to external agencies such as acute injury to the palm or oft-repeated stresses; (2) that it is constitutional in origin. Keen, Adams, and Anderson, three leading writers on the subject, lay more stress on the second theory. Sir Robert Jones thinks the cause is probably a predisposition in an individual with palmar irritation as an exciting cause. Kenneth Black, to whose comprehensive article in the *British Medical Journal*, 1915, 1-326, the reader is referred, states that he believes it will eventually be recognized to be due to a certain internal condition (possibly akin to gout or rheumatism) among persons of advancing age.

The case which I have reported above occurred in a healthy young adult as the result in each instance of injury to the hand. But we cannot deny, of course, that some predisposing internal condition was also present, although he presented no rheumatic or gouty tendencies.

Two methods of treatment of Dupuytren's contracture have been employed; the non-operative, and the operative. Among the former may be mentioned the long continued use of splints, massage, and manipulation, the use of fibrolysin, ionic medication, X-ray treatment, and the internal administration of thyroid extract. These may all be dismissed as of no value.

Dupuytren advocated an open transverse incision and allowed the wound to heal by granulation. This method would not be employed by modern surgeons.

William Adams practised subcutaneous division of the fascia followed by long continued use of splints. This method is open to the objections

that it frequently fails entirely to relieve the condition, that relapses occur, that it occupies a long period of time during which the patient is unable to work, and that permanent stiffening of the fingers not infrequently results from the long splinting.

Paul Berger employs a wide excision of the skin and fascia and a transplantation of a skin flap from the chest. Professor J. Hutchinson says that this method has nothing to recommend it.

The remaining methods of operation have consisted in excision of the fascia by means of various flaps or longitudinal incisions. Kenneth Black says that "skin flaps are dissected from the palmar fascia, the fascia is excised, and the wound is closed. Greatest care in asepsis must be observed, for if the wound suppurates the operation will fail and the resulting contracture will be excessive. The operation is not easy, it requires patience. Dissection of the skin from the fascia is troublesome, and the excision of the fascia from the tendon sheaths must be done bit by bit. Then splints must be employed for weeks."

Professor J. Hutchinson—Hunterian Lecture, *Lancet*, 1917, 1-285—in one of the most recent articles on this subject states that: "(1) The main incision should be linear and vertical over and closely parallel to the ridge of palmar fascia. Small transverse incision at the front of the web may be needed to excise any prolongation of fascia in front of the first phalanx. (2) In the case of the middle and ring finger it is impossible to avoid placing the incision towards the mid-palm. In the case of the little finger alone the incision may be made rather to the ulnar side of the hand where the skin is more supple and less subject to pressure." He adds that V- and Y-incisions are no good as they cause too much scarring of the palm.

The advantage of an incision along a transverse crease of the palm is too evident and too well known to surgeons who have operated upon the hand to require discussion. The same principle applies to surgery in any portion of the body; an incision along a natural crease of the face, or the neck, or the elbow, or the wrist will occasion much less scar, keloid overgrowth, or contracture than an incision transverse to the creases. But I do not find in a search of the literature that any writer has advocated the use of such an incision for the excision of the palmar fascia. That the operation through such an incision is not unusually difficult is demonstrated in the case presented before you this evening.

In regard to the third step of the operation, the implantation of a free fat transplant, I was not aware at the time of operating upon this case that this procedure had been employed in Dupuytren's contracture. But I have since read an article by Dr. Alfred Peiser in *Zentralblatt f. Chir.*, Leipzig, 1917, xliv, 6-8, in which he advocates the use of a free fat transplant following the excision of the fascia through a flap incision whose base is toward the thumb. He states that a search of the litera-

ture shows that the free fat transplant had not yet been used in Dupuytren's contracture.

Spitzzy employed free fat transplants in cases of contracture of the fingers and hand other than Dupuytren's contracture (*Zeitschr. f. orth. Chir.*, Stuttg., 1915, xxxv, 550-561).

While I have operated upon but one case, and it of recent standing, by the method above described, and am familiar with the objections which may be offered on this account, nevertheless, I am convinced that this procedure is in accord with sound surgical principles which have been frequently demonstrated in my own experience and in that of many others in plastic surgery of the hand and forearm.

GUNSHOT INJURY OF THE MUSCULOSPIRAL NERVE*

By FRANCIS REDER, M.D.
OF ST. LOUIS

A MUSCULOSPIRAL nerve injury with its sequelæ presents phases of unusual interest. The nature of the lesion, the time of its infliction and its location have an important bearing upon any prognostications that might be ventured.

The seriousness of a nerve injury can never be accurately judged from the symptoms observed. Nerve damage may be slight, yet the injured portion of the nerve may be lying in a mass of lacerated tissue and suffer seriously through the resulting cicatrization of these damaged structures. An apparently mild trauma of a nerve can engender changes in its internal architecture that may result in completely blocking its conductivity. A nerve injury exhibiting consequences which can be directly ascribed to it, has only one alternative, that of careful exploration and investigation. An exploratory measure promptly undertaken will not only clear up any suspicion of nerve damage, but it will, in case the nerve requires no surgical aid, be of material benefit in removing clotted blood and otherwise caring for the wounded nerve if it be in the immediate proximity of damaged bone.

Should the nerve injury require suture, then the exploratory measure will prove of definite value, inasmuch as primary suture of a damaged nerve gives a far better prognosis for anatomic and functional restoration than does late suture.

A few of the above facts are embodied in a gunshot injury of the left musculospiral nerve in a young woman who was attacked, the assailant facing her and standing at an oblique angle about 5 feet distant when he fired the shot. The ball, a 25-calibre missile, entered about 1½ inches above the anterior axillary angle and, ranging downward, found its exit at the posterior axillary angle. About eight hours later, when the patient was seen by me, she had fully recovered from the shock and the only condition that seemed to distress her was inability to use the left arm and hand. From the condition of the left hand, which was in a pronounced "wrist-drop" position, the inference could be readily made that the musculospiral nerve had been injured.

The paralysis of the triceps, the extensores carpi ulnaris and radialis, the extensor communis digitorum, all the extensor muscles of the thumb, together with loss of sensibility of definite areas in the back part of the arm, forearm and hand, gave evidence that the

* Presented before the Southern Surgical Association, December 17, 1918.

nerve was seriously injured; in fact, the diagnosis of complete division of the nerve was ventured. An immediate operative measure was suggested to the patient and was accepted. The location of the wound caused by the bullet made it speculative as to the best method of approach to the injured nerve. An oval flap joining the points of entry and exit with its concavity upon the inner part of the upper arm was decided upon. The flap was dissected down upon the chest wall and the axillary space fully exposed. The approach proved to be a very satisfactory one.

The removal of much clotted blood revealed the anatomic structures and by a careful dissection the relationship of vessels and nerves became readily demonstrable. After a thorough inspection of the musculospiral at the supposed site of injury, much to my surprise everything was found intact—not only did I fail to find a divided musculospiral nerve, but I could not even see where an injury to the nerve had taken place. It was an exasperating condition to be in, and I began to feel as though I might be lacking in definite anatomic acquaintance. In my desperation there came to memory an interesting dissertation on nerve injuries, known as concussion. The characteristic feature of such an injury is that the nerve is not touched, but is damaged by the vibrations caused by the passage of the bullet. These vibrations can be sufficiently severe to affect the nerve fibres and cause conductivity to be suspended, making it often impossible to clinically distinguish between severe concussion and nerve division. Strong as was my inclination to accept this version, I could not reconcile myself to apply it in this case, and the search for the lesion was continued. That my anatomical interpretation of the surgical field might have caused me to err, did not weigh heavily upon me, because I never lost faith in the size of the nerve held under suspicion—it was the largest nerve present. Furthermore, I felt certain of the location of the nerve as the structure was found behind the axillary artery upon the subscapularis, teres major, and latissimus dorsi muscles, and could be followed backward upon the long head of the triceps toward the musculospiral groove. Furthermore, the superior profunda artery was recognized in the immediate vicinity. This vessel was severed by the bullet. Manipulation of the structure dislodged the clot and the vessel started to bleed, making it easy of recognition. Fortified with these anatomical facts the identity of the musculospiral nerve seemed absolute. Imbued with the certainty that the nerve had suffered an injury, a most assiduous investigation was instituted. With the aid of a gentle irrigation of saline solution the field was cleared of all accumulated blood that vision might not be hindered. Viewing that portion of the nerve which lay in the track of the bullet, nothing unusual presented itself, the nerve appearing smooth and symmetrically rounded. Upon very close inspection, however, there could be seen upon the middle of the nerve sheath a reddish brown line about $\frac{1}{2}$ inch in length, running parallel with the axis of the nerve. An endeavor to

brush away with gauze this reddish brown line was unsuccessful. It was then that the thought obsessed me that the bullet passed through the nerve, without inflicting gross damage to its investing sheath.

It became now an easy matter to demonstrate the injury. With two delicate forceps the neurilemma was caught in the immediate vicinity of the reddish brown line and by gentle traction in opposite directions the opening in the nerve was readily disclosed. The reddish brown deposit, which was coagulated blood clinging to the lacerated nerve sheath, was continuous with extravasated blood upon the internal structure of the nerve marking the path of the bullet. On the side of the nerve where the missile found its exit, a similar deposit of coagulated blood was seen clinging to the torn neurilemma.

Inspection of the wound in the nerve made it apparent why conductivity was lost. It now became a matter of speculation to what extent the axis cylinders and the minute internal architecture of the nerve had been destroyed. This was of much importance, inasmuch as the care of the wounded nerve depended upon some definite conclusion. Examination of the nerve trauma, after all extravasated blood in the path of the bullet had been removed by gentle scraping with a sharp knife and douching with saline solution, revealed nothing whereby the extent of the damage to the nerve structures could be judged. The clinical picture, depicting complete paralysis and loss of sensation, gave the only positive evidence of the seriousness of the injury.

In deciding upon a surgical measure for the wounded nerve, the guiding principle reposed in the proper approximation of the axis cylinders and the prevention of connective tissue intervention from the outside during the process of repair. The question of suturing the wound in a manner that would pucker the nerve was considered. It was, however, dismissed on account of the pressure the suture would exert upon the nerve tissue and the unavoidable tension which would be caused by the puckering, two conditions that must be avoided in nerve surgery.

The most feasible measure for this character of injury seemed to be the one which assured good apposition of all neurological structures in the track made by the passage of the bullet. It was reasoned that a gentle compression of the injured portion of the nerve, maintained for about two or three weeks, would give just as accurate an axonal contact and hold out just as encouraging an outlook for the regenerative potency of the nerve, as would any other surgical measure less free from traumatism.

In accepting this procedure the fact was borne in mind that a nerve which had been injured so that its axis cylinders are seriously damaged is prone to develop in it a type of connective tissue through which the axis cylinders do not subsequently pass and which leaves a permanent paralysis.

The application of this gentle compression measure entailed a



FIG. 1.—Showing incision of approach to musculospiral nerve.

simple technic, the only additional traumatism being the borrowing of a strip of muscle tissue from a convenient muscle—in this instance the strip was taken from the long head of the triceps, sufficiently large to be wound around the injured portion of the nerve with a generous encroachment upon its uninjured part. To make the compression effective, it was necessary that both ends of the muscle strip be secured. This was done by anchoring the ends with a catgut suture to muscle tissue in the immediate vicinity.

This procedure embodied two principles: that of compression sufficiently firm to make axonal contact certain, and that of prevention of connective tissue intervention from the outside. In all nerve injuries it is desirable to have a union free from the ordinary connective tissue type. All repair must be made by means of the proliferation of glial tissue in the large axones. It is the neuroglial type of connective tissue with its positive chemotactic attraction which favors the transmission of the axis cylinders and is of great value in nerve regeneration.

In choosing muscle tissue over other tissue, such as fat or fascia, a definite purpose was entertained. In muscle tissue there is an elasticity and a tone absent in fat. With fat only an unsatisfactory compression could have been accomplished, whereas with a fascial strip the purpose might have been accomplished with the risk of exercising too severe a prolonged compressing of the nerve on account of the density and inelasticity of the tissue. This would have most likely defeated the purpose for which it was intended. The strip of muscle tissue embodied all the requisites called for and the subsequent regeneration that took place with complete restoration of function and sensation gave full attestation to its value.

After closure of the skin wound and proper drainage of the axilla, the wrist-drop was held slightly over-corrected, with the arm and hand resting upon a comfortable splint. Fortunately for this patient the healing of the wound was not retarded by inflammation. For the first ten days there was a marked œdema of the fingers and hand, extending to about the middle of the forearm. The œdema subsided slowly and had fully disappeared when patient left the hospital three and one-half weeks later.

The following data were obtained as the patient presented herself for examination:

Two months after the injury, which happened December 30, 1917, 2.30 A.M., no sensory nor motor recovery was in evidence. The muscles of the hand and forearm appeared atrophic. On March 28th, twelve weeks after the injury, patient called and stated that two days ago she was able to move her fingers. Examination revealed that sensation (pin prick) in the anæsthetic regions had returned and that the patient was able to slightly move her wrist and her fingers at the metacarpophalangeal joints. On May 30, 1918, twenty weeks after the injury, a marked

improvement had taken place both in sensory and motor recovery. Although the wrist-drop was still pronounced, she was able to extend and flex her fingers to about $\frac{4}{5}$ normal. On July 16, 1918, twenty-six weeks after the injury, the wrist-drop had greatly improved. There was, however, still a slight finger drop. Patient was able to grasp and hold objects with a sense of security. The muscles of the hand had taken on their normal appearance.

On October 28, 1918, forty weeks after the injury, the wrist-drop had entirely disappeared. The patient was able to extend and flex her fingers in a normal manner. Sensory and motor recovery had been fully restored with the exception that there still was a peculiar "dead" feeling in the ends of her fingers and that she was not yet able to pick up a pin.

THE APPLICATION OF EXTENSION TO OVERLAPPING FRACTURES, ESPECIALLY OF THE TIBIA, BY MEANS OF BONE SCREWS AND A TURNBUCKLE, WITHOUT OPEN OPERATION *

BY LEONARD FREEMAN, M.D.

OF DENVER, COLO.

THE procedure herein described deals with the management of fractures of the tibia requiring forcible and prolonged extension which cannot be obtained satisfactorily by ordinary means.

The difficulties encountered in handling such fractures are well known, and the outcome is often unsatisfactory, as has been emphasized by Sir Arbuthnot Lane and others.

In most instances the bad results are due to overlapping of the fragments, leading to shortening, deformity and distortion of the weight-bearing axis of the limb. It is universally recognized that this generally can be overcome by sufficient extension properly applied; but to apply sufficient extension is not always easy by means of the devices usually employed.

The most common expedient is the use of a weight, cord and pulley; the cord being attached to the leg by means of adhesive strips, by a stocking glued to the skin, a shoe, or to a nail or wire passed transversely through the os calcis, according to the suggestion of Steinmann and Codivilla.

Difficulties present themselves in all these methods. For instance: When the break is low down there is insufficient room to apply adhesive strips or a stocking firmly enough to sustain the required weight. In addition, they are often out of the question in compound fractures or when there are abrasions, eczemas or blisters. A shoe is apt to be uncomfortable and impede the circulation of the foot, while the Steinmann procedure, although excellent in some respects, has certain drawbacks common to all the methods mentioned, in that it is cumbersome, takes up unnecessary room, puts great strain upon the joints of the ankle, knee and hip, and immobilizes these joints in a way that leads to stiffness and prolonged disability, to say nothing of the inhibition of the patient's movements.

In fact, the shortcomings of extension, as usually applied, are so real, and its results so unsatisfactory, that many surgeons have been led to adopt open operation as the method of choice. Without denying that this is sometimes preferable, it may, under unfavorable circumstances, lead to sepsis or delayed union. At best it is often a complicated undertaking requiring prolonged anæsthesia, much experience, and a faultless

* Read before the Oregon State Medical Society, June 26, 1919.

technic—occasionally appearing to the patient as more formidable than the condition would seem to indicate.

In order to overcome these difficulties I have recently devised a method of extension to which I desire to call attention.

Technic.—The instruments required (see illustrations) are: (1) Several *strong*, steel bone-screws, about $2\frac{1}{2}$ to 3 inches in length and $\frac{3}{16}$ of an inch in diameter. (2) A drill making a hole slightly smaller than the screws (ordinary machine twist-drills are the most suitable). (3) A properly constructed turnbuckle. (4) A long clamp for holding the screws in position after adjusting the fracture.†

The operative steps are:

1. Obtain an X-ray picture of the break, noting the amount of overlapping of the fragments.

2. Prepare the skin as in any other operation.

3. Under general anæsthesia, adjust the fragments roughly, especially as regards rotation, being careful that the inner border of the foot is on a line with the inner border of the patella.

4. With a sharp-pointed knife make two small, button-hole incisions over the centre of the flat surface of the tibia, one on either side of the break and at some distance from it. They should be just large enough easily to admit the drill and should reach to the bone.

5. Insinuate the drill through the soft parts and bore clear through the medullary cavity, so that the instrument obtains a firm hold in the posterior osseous layer.

6. Remove the drill and replace it with a bone-screw, which gets a firm fixation because it is slightly larger than the drill, and penetrates both sides of the bone.

7. When the screws have been placed, one above and one below the fracture, insert the turnbuckle between them, close to the skin (Fig. 5), and apply extension, corresponding in degree to the over-riding of the fragments, previously noted by the X-ray, or by measurement of the opposite limb. When possible the progress of the adjustment may be observed through a fluoroscope.

8. Place the clamp upon the screws, as low down as practicable in order to reduce the leverage, thus maintaining the extension (Fig. 6), after which remove the turnbuckle. If either fragment tends to project forward beneath the skin it should be pressed into place before adjusting the clamp.

9. Apply dressings and a bandage. If only two screws have been used a light splint may be desirable to maintain the general alignment of the limb.

The after-treatment consists in changing the dressings every few days and painting the skin around the screw-holes with 2 per cent. tincture of iodine.

† These instruments can be obtained from W. H. Lauth, 1632 Court Place, Denver, Colorado.

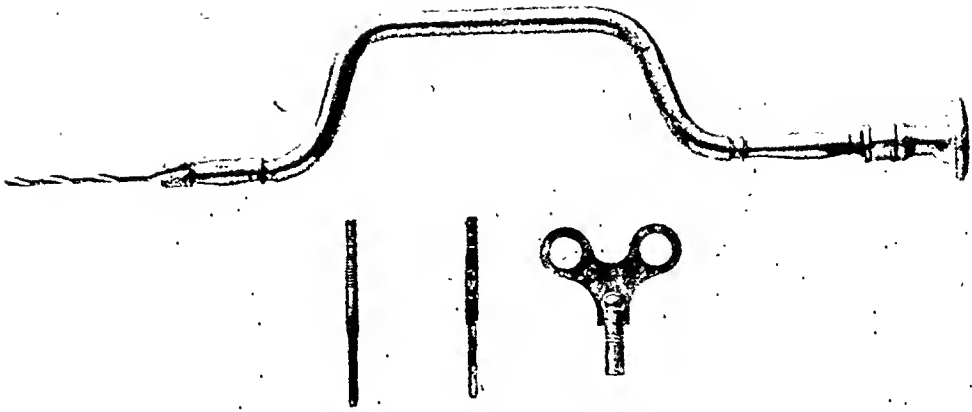


FIG. 1.—Bone-drill in brace. Bone-screws and clock-key, the latter fitting the squared ends of the screws and also used to tighten the bone-clamp.



FIG. 2.—Side view of bone-clamp.

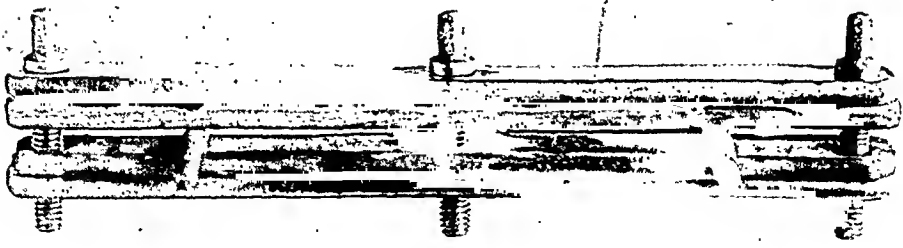


FIG. 3.—Top view of bone-clamp, showing lining of soft wood in which the bone-screws become firmly embedded when the clamp is tightened.

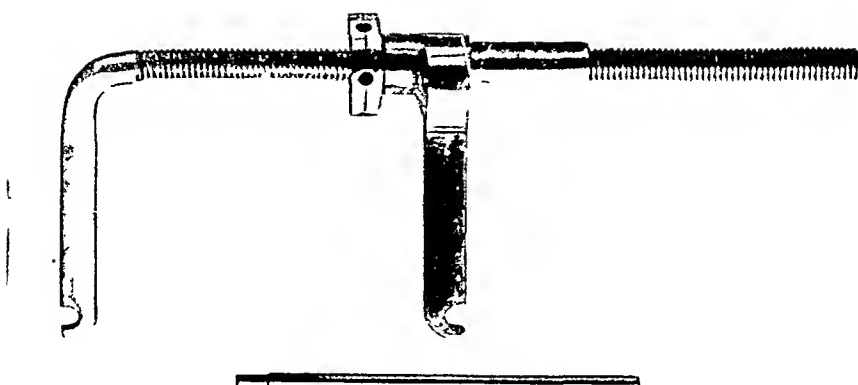


FIG. 4.—Turnbuckle

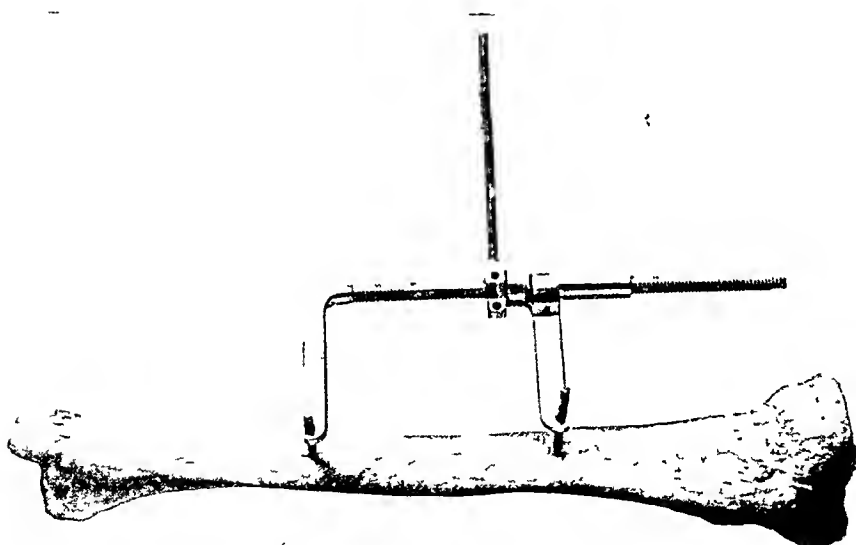


FIG. 5 —Turnbuckle in position for applying extension

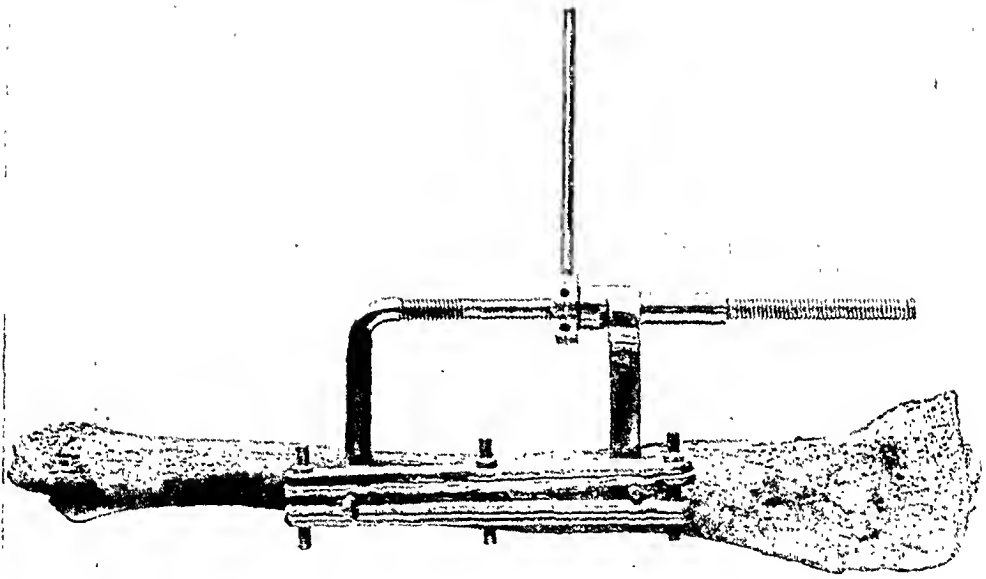


FIG. 6.—Bone-clamp in position before removal of turnbuckle.



FIG 7.—Fracture of bones of leg with deformity (taken in splint).

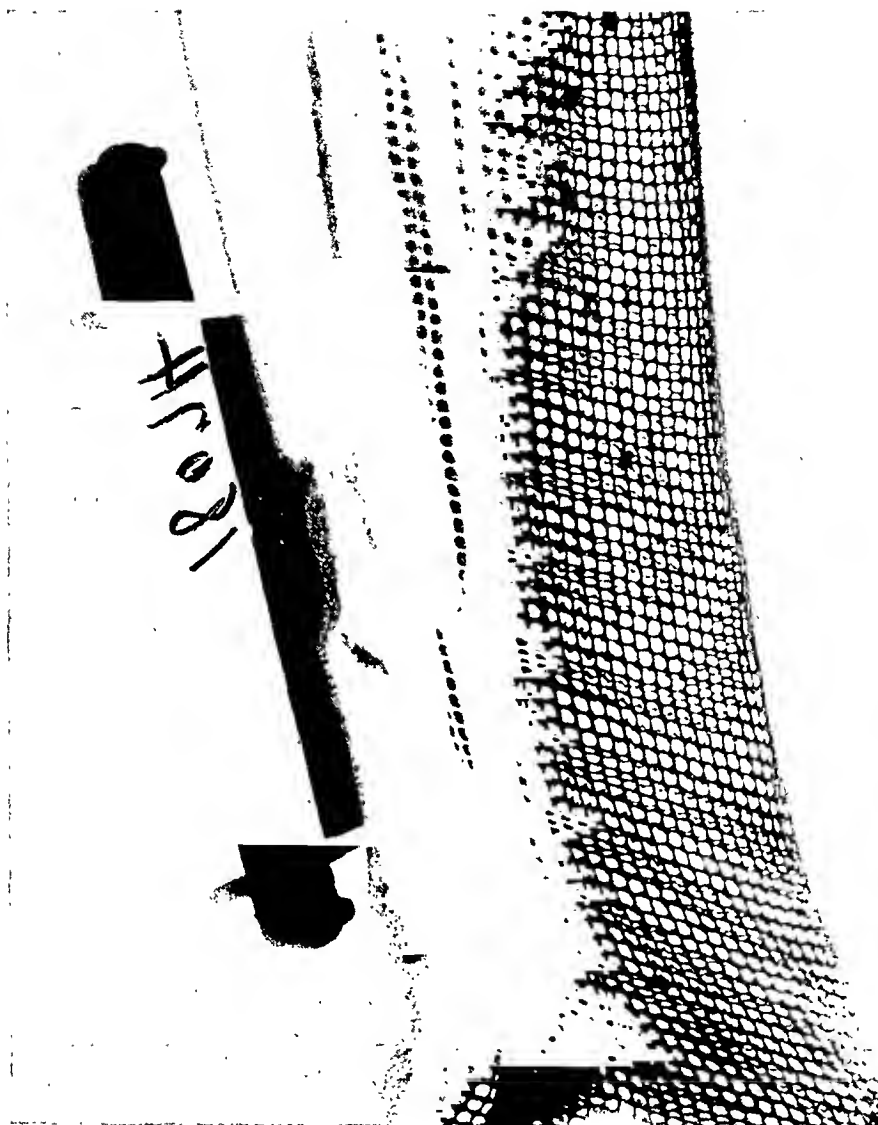


FIG. 8.—Same as Fig. 7 after clamp extension (taken in wire splint).

If desired, the apparatus may be left in place for a number of weeks without hesitation, although in most cases sufficient union to permit of its removal in two or three weeks will have been obtained. Extensive experience during the late war with the Steinmann nail-extension and the caliper extension of Ransohoff has strongly emphasized the fact that nails, screws and calipers inserted into bones and left projecting through the skin may remain in position for a long time without infection, thus adding important testimony to the already abundant evidence gained with the external bone clamp.‡

When removal of the apparatus is decided upon, it is easily accomplished by taking off the clamp and unscrewing the screws from the bone. No anæsthetic is required, as but little pain is produced, or none at all. The holes are then painted over with tincture of iodine and usually close in a few days. A splint or a light case may be applied until consolidation is complete.

If one wishes, two screws can be inserted on each side of the fracture instead of one, thus gaining additional firmness, but this seems hardly necessary in the majority of instances.

By using a sufficiently long clamp one or both screws often can be placed far from the fracture, in sound tissues, thus avoiding disturbance of the injured parts—manifestly a desirable thing to do.

Attention should be called to the large amount of force at the disposal of the surgeon. In fact, it is limited only by the strength of the screws and the solidity with which they are embedded in the bone. A moderate amount of temporary, or even permanent, over-extension may be desirable, to aid in the replacement of fragments. This powerful extension, so easily, accurately and safely applied, enables one to overcome readily any amount of shortening, even after the lapse of a number of days, in spite of contraction of the soft parts, a feat which otherwise is hard to accomplish short of an open operation. I have done this as late as five or six days following the injury. At the same time that the shortening is overcome, the axis of the bone is brought into line and even displaced fragments may be replaced (Figs. 7 and 8). This action is due not only to the extension, but also to the side pressure of the soft parts produced by the tension under which they are placed.

The use of an external clamp causes very little discomfort—much less, in fact, than ordinary extension. This is because the fragments are held firmly, even during muscular spasm, while the soft parts and joints are free from the constant strain of a suspended weight. The surgeon's mind is also relieved of uncertainty regarding the amount of weight to be employed and the relative positions of the fragments.

In this connection it should be borne in mind that, however large the

‡ From an experience with 57 fractures of the femur, Bulkley and Sinclair conclude that "The ideal form of traction is skeletal, and this form of traction is practically without danger." *ANNALS OF SURGERY*, May, 1919, p. 492.

clamp may be, it lies entirely outside. The penetrating portions of the bone-screws represent a much smaller foreign body than does an internal bone-plate, and, unlike the latter, are situated at a distance from the seat of the injury. In fact, the comparative comfort of "clamp patients" is often a matter for comment.

It is, of course, apparent that the intervention of soft-parts, the twisting of the bones in spiral fractures, etc., may prevent reposition of the fragments and necessitate an open operation; but these things are exceptional and likewise apply to other methods of extension. Also, it is evident that the clamp will work better when the break is not too near the end of the bone; not only owing to lack of room for the screws, but likewise because the cancellous tissue gives them a less firm hold. Nevertheless, I have used it with satisfaction in such fractures.

To Dr. Clayton Parkhill,¹ of Denver, is due the credit of suggesting and popularizing the use of the external bone-clamp, in this country, at least. It was previously employed by Keetley, of London, and possibly others, but of this I am sure Doctor Parkhill was not aware. The Parkhill clamp, however, is so complicated that it is often discouragingly difficult to adjust, which is also true of other clamps, such as that of Lambotte. In addition, its construction is such that the screws cannot be placed at a distance from the fracture, and it is also impossible to use it for purposes of extension. My own clamp² (Figs. 2 and 3), consisting of two strips of metal lined with soft wood, is extremely simple and easy of application and permits of placing the bone-screws at any desired distance from each other and of varying this distance as required. Its efficiency has been demonstrated by its use for fifteen or twenty years, by myself and others. It is unnecessary to be provided with many clamps of varying lengths, one long one being sufficient for nearly all cases, even those in which the screws must be placed quite close together. Whether but two screws are employed or several (for the sake of greater firmness) is of no importance, providing they are placed in line with reasonable accuracy.

So far I have had no opportunity of applying the method of clamp-extension to any fracture except of the tibia, the initial operation being done on December 7, 1918; but I can see no reason why it should not be used upon other more or less superficial bones, such as the ulna and even the clavicle. (With the clavicle the drills and screws would have to be furnished with appropriate shoulders to prevent them from penetrating too deeply and injuring the underlying structures.) I have even wondered whether a broken femur could not be stretched in this manner by placing one screw just above the external condyle, as in the Steinmann nail-extension, and the other near the trochanter, where the bone is superficial.

To summarize the advantages of clamp-extension:

1. Facility of application and absence of cumbersome apparatus.

APPLICATION OF EXTENSION TO OVERLAPPING FRACTURES

2. Effectiveness of the extension and exactness of its amount, as regulated by the X-ray or by measurements of the opposite limb.

3. Its applicability in the presence of open wounds and lesions of the skin, and its freedom from injury to the skin.

4. Absence of strain upon the articulations and soft parts and freedom of the patient to move both himself and his joints.

5. Comfort and safety from infection and avoidance of an open operation.

6. Placing of the screws at a distance from the break, thus avoiding disturbance of the injured tissues and the danger of increasing the likelihood of delayed or non-union.

7. Easy removal, without anæsthesia.

8. Admitting that the adjustment of the fragments sometimes may be less exact than with an open operation, nevertheless, the length and weight-bearing axis of the limb may be conserved by means of the extension-clamp, which, after all, is the main object in view.

It should be noted that Desguin,³ in 1907, described a method of extension of oblique fractures of the tibia by means of complicated turn-buckles with their ends embedded in plaster casts applied about the limb above and below the fracture. Although the procedure is undoubtedly useful under certain circumstances, it is cumbersome, uncomfortable, apt to disturb the circulation, and cannot be used unless the skin is intact. The method has never become popular, perhaps for these reasons.

Since writing the above paper my attention has been called to an article by D. W. Crile,⁴ in which he described a heavy and complicated apparatus for extension in fractures of the femur. Double-pointed calipers, applied to the femoral condyles, are used to control the lower fragments, while a large, square spike is driven into the trochanter. These are connected to a telescoping, socketed, steel bar by ball-and-socket joints.

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³ L. Desguin: "Reduction and Contention des Fractures Obliques de la Jambe," Ann. de la Soc. Médico-Chirurg. d'Anvers, 1907.

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CANCER OF THE STOMACH AND ITS SURGICAL TREATMENT*

BY CHARLES H. MAYO, M.D.

OF ROCHESTER, MINNESOTA

PROBABLY no word in medicine is more depressing to the patient than that of cancer in the diagnosis of his disease. We are assured by most clinicians that cancer is on the increase; possibly this increase is more apparent than real and is due to the greater general diagnostic ability of the medical profession and the better facilities for obtaining statistics. A general knowledge, as well as fear, of the disease is gradually spreading, largely the result of the propaganda of the publicity committee of the American Medical Association, and the work of the special cancer commissions, all of which is creating a favorable evolution of opinion, and causing more persons to seek treatment during the earlier stages of the disease.

The most common cancer is that of the stomach. More than one-third of the cancers in men and more than one-fifth of the cancers in women appear in this organ, and inasmuch as the condition in nearly one-half of such patients who come to the physician for examination is inoperable, there is room for some improvement in the matter of securing earlier recognition of the disease. At best, however, the gain will be comparatively small over present conditions, because in many instances the disease gives but few symptoms until it is far advanced, and because approximately 75 per cent. of cancers of the stomach are so located or of such a type that early metastasis takes place into glands and into other organs, or it may become grafted throughout the peritoneum; to prevent this early operation is essential. About one-fourth of gastric cancers are confined to the stomach, and in this group if glands are involved they are in or connected with its wall without papillary outgrowth. These are the most favorable cases for operation, and yet all of this type are not operable for various reasons, advanced age, general debility, complicating diseases, or extensive involvement of the stomach. In the inoperable group may be placed the cases involving the cardia, approximating 10 per cent. of the gastric cancers.

The literature concerning the general subject of cancer, especially of its etiology, is voluminous. Usually such articles are written with the object of proving special theories: for example, that cancer is or is not an hereditary disease, that it is caused by some unknown infection, or that this infection is water-borne, that it is due to malnutrition, general and local, and hence is a medical disease; that it is due to acids, especially of the sulphurous type, or to the excess of cholesterol.

* Presented before the American Surgical Association, June, 1919.

Cohnheim's theory of tissue displacement as a cause has long since been refuted. In taking a general survey of the various theories and reviewing the clinical evidence, it would seem that not one, but several conditions are essential to the development of cancer. The influence of heredity probably does not extend beyond an inherited cell weakness in which extra demand on the cell for division may early exhaust its controlling agent. The great influence of local irritation, which in some instances is undoubtedly chronic infection, is a fact quite generally accepted. No one theory, however, can account for the change in the cell that causes it to adopt lawless existence and to lose its harmony with community life. There is little change from the normal in the cancer cell, yet by the microscopic study of a group of cells and their relationship to surrounding tissues, cancer can be identified positively. An acid condition in the surrounding fluid also seems essential to cancer activity. Hot drinks are probably a cause of no little importance in producing cancer of the stomach.¹ Chronic ulcer is the most important factor to be considered in these cases, as in well over 40 per cent. there is a history of ulcer varying from many months to several years before the onset of cancer. When seen early such cancers are found to have developed on the margin of an ulcer. In such location the demand of cell renewal is constant; when some cell exhausts its controlling granules in the division, and reverting to single cell type, becomes parasitic, we may have the beginning of cancer, but only if other factors are present. The type and growth is dependent on the basal cell and the environment. In a general way it may be said that the nucleus is proportionately larger in the cancer cells, and is ready for division with less than the average amount of cytoplasm surrounding it. Individual cells, as well as groups, must be studied. The various parts of the cell, taking different colors through the varying action of stains, show the complex chemical structure of the protoplasm. It is within reason to assume concerning the normal division of a cell that its control is the centrosome; possibly other granules may serve this purpose. Cell growth in cancer is undoubtedly stimulated by acidity or greatly lowered alkalinity. In this connection it is of interest to mention the work of Loeb. He found by a brief immersion of the unfertilized eggs of sea urchins in a 1 per cent. solution of butyric acid and sea water, that the eggs became fertilized and took on active growth; without sperm. On the other hand, it has been shown that eggs of certain types of lower animals that develop in water, when placed in 0.6 per cent. saline solution develop with frequent anomalies, especially of the higher nervous system, the last addition in evolutionary life.

The greatest number of cancers come in the area of highest acidity, the stomach. Ninety-eight per cent. of intestinal cancers are in the colon, while cancer in the small intestine is relatively rare—about 2 per cent. Cancer in the urinary bladder is not uncommon, while in those organs

¹ Mayo, W. J.: Cancer of the Stomach. Surg., Gynec., and Obst., 1918, xxvi, 367-370.

with a limited period of activity, such as the breast, uterus, and prostate, a normal degeneration often becomes a pathologic one, the stimulating influence probably being of a chemical nature. Cancer of the duodenum is exceedingly rare, yet ulcer of the first portion of the duodenum is nearly four times as frequent as ulcer of the stomach, and while there is opportunity for involvement by continuity of tissue from the most frequent site of cancer in the body, the stomach, this does not occur. Ulcers appear in the first portion of the duodenum as it is bathed by the acids of the stomach before they are neutralized by the secretion of Brunner's glands; ulcers do not appear in the alkaline portion of the intestine below the common duct, although they may be found in a gastrojejunal opening which has there been rendered acid.

While I am not presenting this subject from the standpoint of diagnosis, I wish to refer to the progress which has been made in the diagnosis of gastric cancer, and to corroborate Carman's observations on the operability of cancer of the stomach as determined by the X-ray. Without the X-ray we would be back to the old methods of determining diagnosis, namely, by cachexia, loss of weight, achlorhydria, obstruction, tumors, etc., which are all signs of advanced gastric cancer. At a time when the cancer syndrome is not positive but probable, the X-ray may be relied on to demonstrate lesions of the stomach in more than 95 per cent. of the cases.

In general the treatment of cancer by radium is proving successful in certain types of the disease which can be reached by the ray; in some instances cure is produced and in others growth is delayed. By care and filtering processes the various rays are controlled. The effect on the cell is chemical, influencing the protoplasm or the local fluids. Radium is most effective in growths with active circulation, as it has a marked influence on the wall of the blood-vessel. It also apparently acts on the cell nucleus, checking division, but it may be used to excess and cause local destruction. The X-ray acts on the cell protoplasm, checking growth, and it may also cause local destruction. Between these two conditions, the X-ray causes rapid epithelial proliferation, areas of which might at times be called pre-cancerous. The cell having lost its controlling granules through the ray's action and retaining its nucleus and cytoplasm will become malignant when surrounded by the proper bio-chemic fluids. This shows that under certain conditions cancer can not only be produced but controlled. As yet radium and X-ray are only palliative or a means of delaying the progress of gastric cancer.

From October 1, 1897, to January 1, 1919, we performed 2094 operations for cancer of the stomach. Seven hundred and thirty-six of these were resections with a mortality of 13.7 per cent., 746 were explorations with a mortality of 2.9 per cent., and 612 were palliative operations with a mortality of 11.1 per cent. The common type of operation was the Mikulicz, Hartmann, Billroth No. 2, of which there were 359, with a mortality of 12.5 per cent.

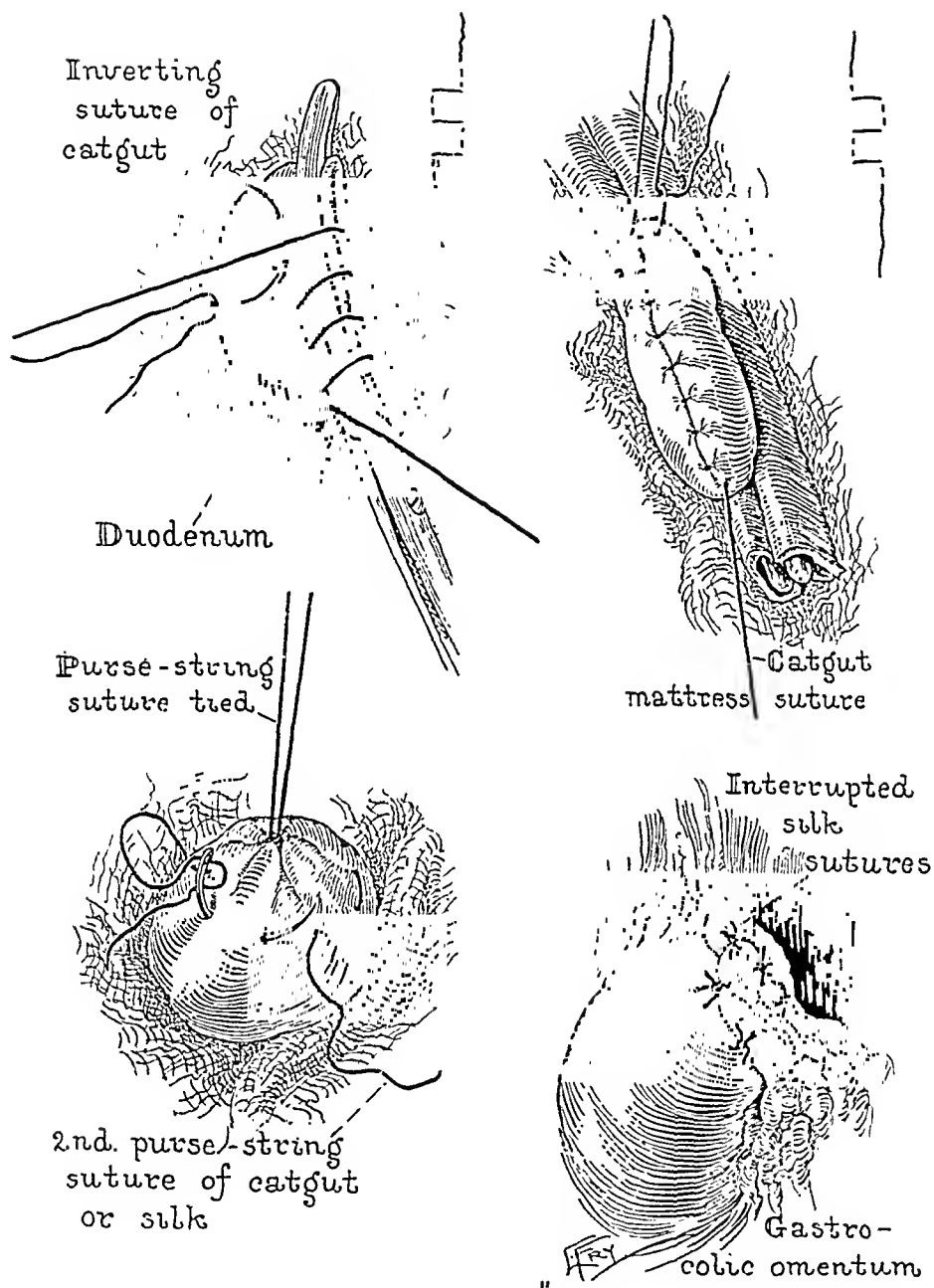


FIG. 1.—Two methods of closing and protecting the cut end of the duodenum.

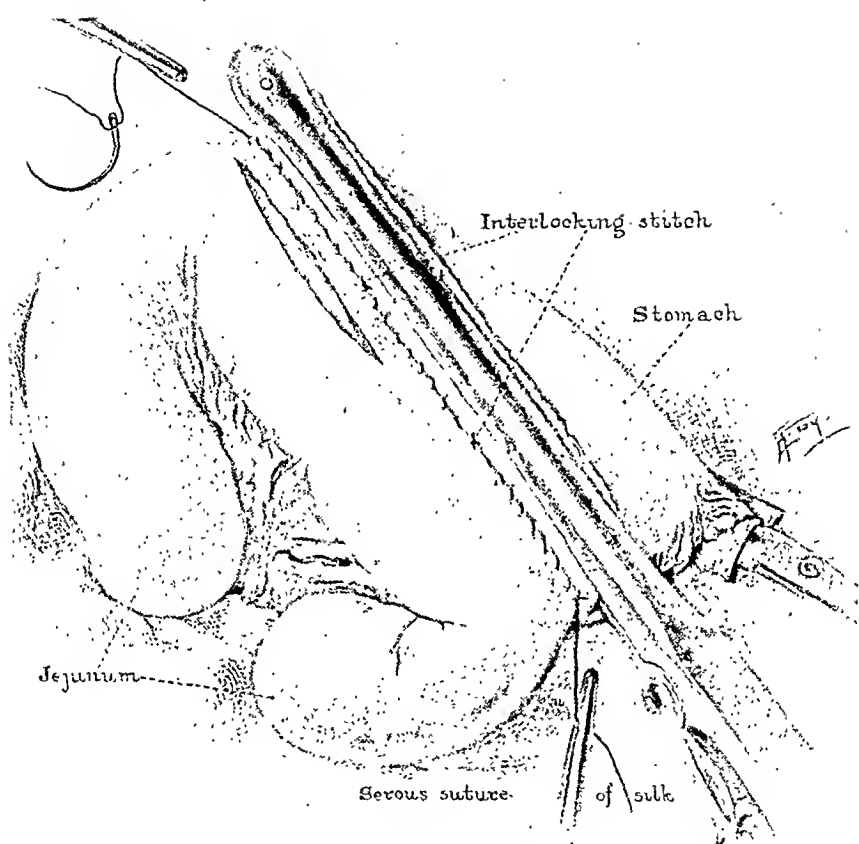


FIG. 2.—Jejunal attachment; approximate size of opening in bowel.

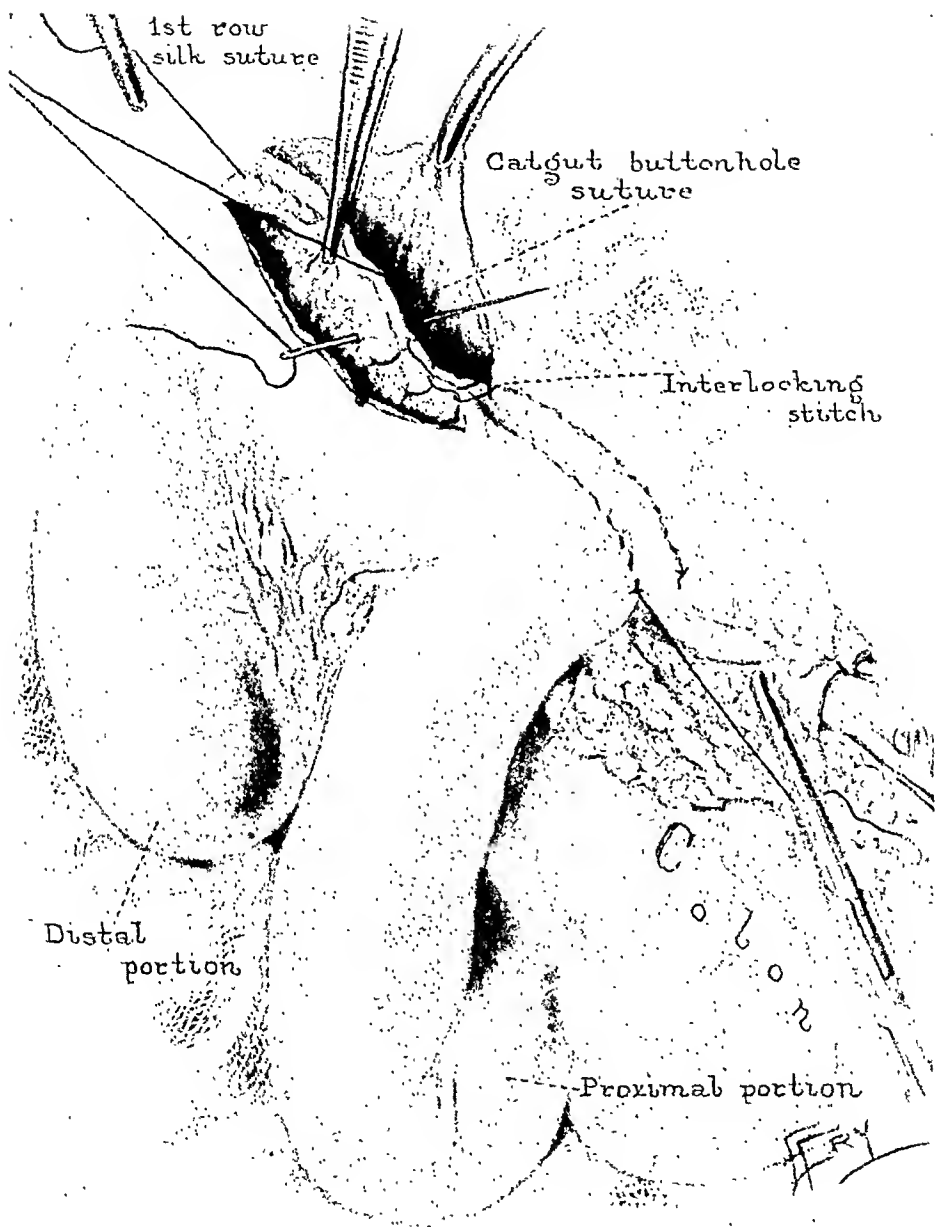


FIG. 3.—Gastro-enterostomy opening with partially closed end of the stomach.

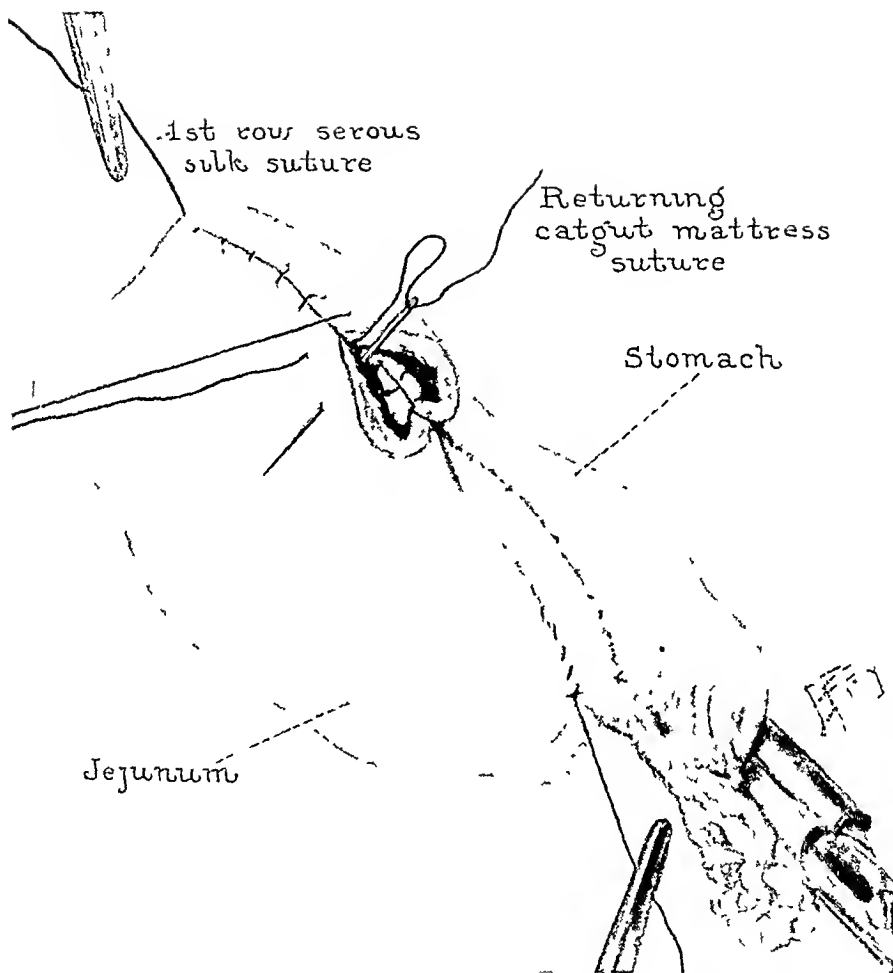


FIG. 4 —Catgut suture closing gastrojejunal opening and continuing over the closed portion of the stomach to reinforce the suture line.

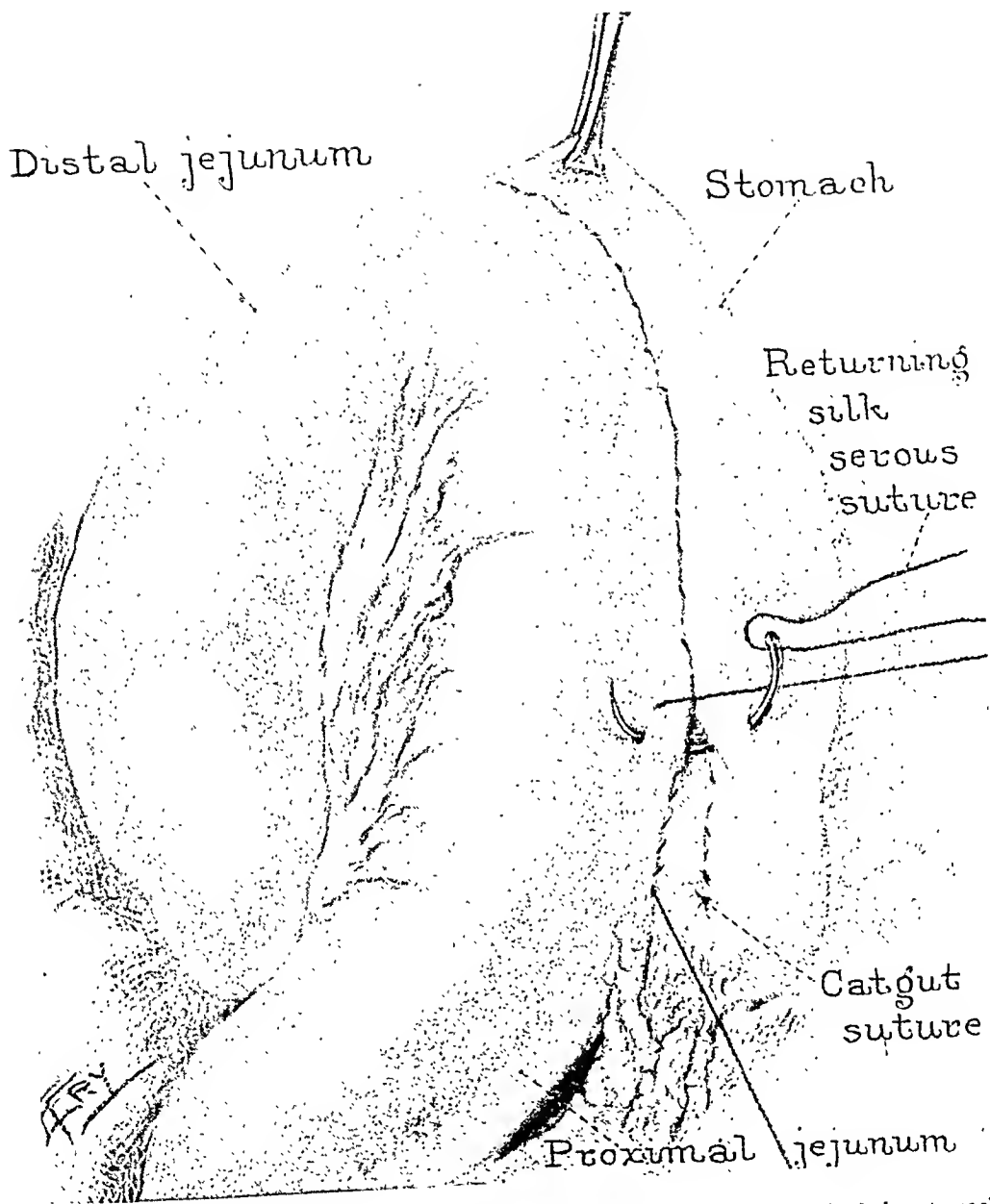


FIG. 5.—Final row—serous suture completing suture line which protects the end of the stomach with the intestine.

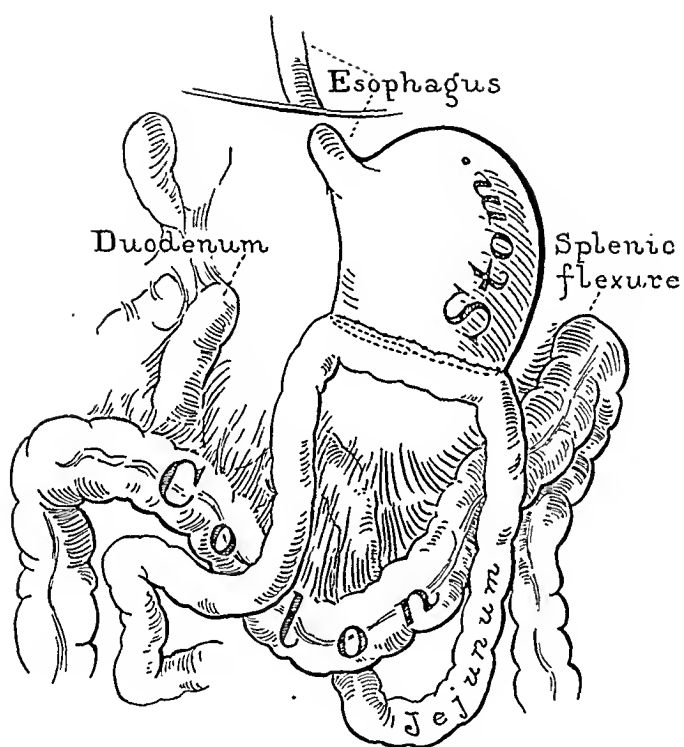


FIG. 6.—Schematic diagram. Method of attaching jejunum and stomach. Omentum not shown.

There were 19 of the Billroth No. 1 type with a 5 per cent. mortality, 28 sleeve resections and 7 Kocher operations with a mortality of 14.2 per cent. each, 115 posterior Polya operations with a mortality of 14.7 per cent., and 120 anterior Polyas with a mortality of 13.3 per cent. The local resections, 12 in number, gave the highest mortality, 25 per cent. These 660 resections have been done since 1906. Prior to this the type of resection was not described in the records definitely enough to be included in a statistical report. The Billroth No. 1 operation consists of a resection of the pyloric end of the stomach, and the suturing of the duodenum to the partially closed distal end of the remaining portion of the stomach. Since the Y-shaped line of suture of this type of operation frequently leaked with fatal results, Billroth, with Mikulicz and Hartmann, developed the so-called Billroth No. 2 operation, which consisted of completely closing the end of the stomach and making a posterior gastrojejunostomy. The Kocher operation avoids the leakage of the Billroth No. 1 operation by attaching the end of the duodenum through an opening in the posterior wall of the stomach after the open end is closed, but tension here occasionally gave obstructive trouble or leakage (Figs. 1 and 2). Polya avoided the double operation of closure of the end of the stomach followed by gastro-enterostomy, by uniting, retrocolic, the whole open end of the stomach to an equal sized opening made in the jejunum. In the Polya operation the newly formed end of the stomach consists of the jejunum, which spreads out as the stomach is filled; the opening may be from three to five inches in length, according to the size of the resected end of the stomach. If the opening is but three inches, the whole end of the stomach may be attached to the jejunum by incising the bowel a nearly equal distance; with each passing of the needle, the suturing loops catch a somewhat greater amount of the wall of the stomach than of the bowel. Since the bowel becomes the stretched-out end of the stomach with an opening at each side of the attachment, proximal and distal, the delivery of gastric contents is not so well accomplished as it is with the partially closed end of the stomach with an ordinary sized gastro-enterostomy opening properly placed (Fig. 3). The mortality rate incident to the various operative methods is nearly the same; there is, however, some difference in the comfort and postoperative condition of the patient. In the operation described herewith this large opening is avoided by attaching the jejunum to the posterior wall of the stomach close to the crushing clamps, which are left on to hold the stomach closed until the first row of sutures is applied. Before removing the crushing forceps the contents of the stomach are controlled by applying long, flexible rubber-covered forceps, slightly higher on the stomach, which prevent its contents from soiling the wound. After the first row of sutures has been made and the crushing forceps removed, the stomach is partially closed by an inturning suture, begun at the greater curvature, closing in toward the lesser curvature until the opening remaining is only slightly greater

than the diameter of the jejunum. The jejunum is now opened opposite this point, a quarter of an inch from the first suture line, and the ordinary technic of gastro-enterostomy is completed. The opening being closed, the suture is continued as a second row over the closed portion of the end of the stomach. The first suture is now continued over the anterior portion, making two rows on the gastro-enterostomy opening, and protecting still further the closed end of the stomach by suturing over it the unopened bowel (Fig. 4).

For the last three years we have been doing the anterior Pólya, the original Kroenlein instead of the posterior, bringing the loop of jejunum over the transverse colon. We abandoned the posterior Pólya because of primary obstructive complications due to adhesions, to tension from gastric traction, or to late trouble from recurrence of the malignancy, with early obstruction. The anterior operation gives an easier convalescence on the average (Fig. 5). I believe that better after-results are secured by turning the bowel to the right, isoperistaltic, which was a marked feature in the earlier operations of anterior gastro-enterostomy. The point of attachment of the jejunum is approximately fourteen inches from its origin, while the opening in the stomach comes directly over the descending leg of its loop, the reverse of the Mikulicz partial closure and button anastomosis. The transverse colon naturally sags in its mid portion; by turning the bowel from left to right it is brought to the left of the centre, while the stomach delivers along its lesser curvature, the more fixed portion of the viscus. Inasmuch as the tissues of the stomach are more or less devitalized by disease and more so by the operation, the suture material recommended is silk for the outer row and chromic catgut for the inner row; the silk guards against separation from delayed healing (Fig. 6). The completed operation can be made within one hour.

Our data bring the results of operation up to September 1, 1917; four hundred and twenty-seven patients were operated on during the three years previous to September, 1917. Those who died in the hospital, and those not heard from, number 121. Those who recovered from the operation and who have been heard from number 306; 115 (37.6 per cent.) of these show three-year cures. Three hundred thirteen patients were operated on during more than five years before September 1, 1917. Those who died in the hospital, and those not heard from, number 79. Those who recovered from the operation and who have been heard from number 234; 59 (25 per cent.) of these show five-year cures. This is a most satisfactory showing for the surgical relief of an otherwise hopeless condition which is attended by much suffering.

THE METHOD OF RECORDING SURGICAL OPERATIONS AT THE FRONT *

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"THEY do these things better in France," is a phrase which had passed into history many years before the great German War, but the truth of which has been verified anew in many respects during the experiences of the last four years. Especially, from the military point of view, did I find this to be the case with the methods of recording surgical operations during the hurry of work in advanced posts. Surgical Team No. 23, U. S. Army, of which I was the senior member, with Lieut. Henry S. Kerchner as my Assistant, together with two nurses, an anæsthetist, and two enlisted men as operating room assistants, worked for three months in a French "Autochir," and it became our duty to put on record in French an account of each operation as it was done. So explicit is the French language, and so nicely does it lend itself to terse and accurate expression, that when later our activities were transferred to an Evacuation Hospital of the United States Army, we carried along with us certain habits of expression which might well be officially adopted into the military code of armies other than the French.

In order for any statements, spoken or written, to be clear and intelligible, it is first and foremost necessary for the speaker or writer to know definitely in his own mind the points he wishes to have recorded and the order of their statement, and for him to employ definite and fixed terms of expression. These habits the French surgeons have acquired, and they gladly pointed out to us the important facts which should be recorded, as well as the value and significance of certain habitual abbreviations.

The patients would arrive at the operating room of the autochir with their "pochette" (the diagnosis envelope) already made out. This had been done at the "Triage" (sorting centre) of the autochir, the patient's name, rank, etc., and the "diagnostic sommaire" (summary diagnosis) being recorded on the outside of the envelope (Fig. 1). Here also was recorded the *date and hour of injury*, whether or not the *injection of antitetanic serum* had been given; and when the patient was dismissed from the operating room or later when discharged from the ward, other notable facts were added on the outside of the envelope, such as the *nature and date of any important operation*; how the patient was to be *transported* (sitting or recumbent); whether he was to be transported only a short distance, or to the intermediate zone,

* Read before the Philadelphia Academy of Surgery, May 5, 1919.

or to the interior; whether he was an officer, a member of one of the allied armies, a Musselman (important because no wine could be taken by such patients), etc.; as well as *treatment required during transport* (diet, *i.e.*, regular, special, or liquid); whether or not *catheretization* was required; the *date of the last dressing* of the wound, and the date when it should be dressed next; and finally the special service to which the patient was to be assigned on arrival at the rear. Most of these facts could be indicated by underscoring or striking out with a colored pencil.

Inside the pochette, on arrival at the operating room, was a slip of paper on which the radiologist had recorded the results of his fluoroscopic examinations. These radiosopic diagnoses were models of accuracy and neatness, considering the great speed with which the examinations had to be made.

For the space of one minute or thereabouts, intervening between the time the surgeon could turn his attention from the last patient to the patient next in order, opportunity was afforded to scan the summary diagnosis on the outside of the envelope, and to read the radiologist's diagnosis. Toward the conclusion of each operation the surgeon would then dictate in French (or, if an American surgeon, then in patois), what was to be recorded for the information of the surgeon into whose care the patient should come at his next station. This dictation, taken down by a clerk (or in emergency written by the surgeon himself, or by any of his staff who understood French), was written on another scrap of paper (paper was valuable and scarce); this also was placed in the *pochette*, and accompanied the patient to his permanent hospital, where "fair copies" could be made of all the scraps of paper which had accumulated on the journey. When time permitted, this fair copy was made in the office of the autochir, in manuscript, on the "Billet d'Hôpital à Coupons" (a folded form on which the Field Medical Card of the United States Army is modelled), and this also was placed in the *pochette*, and was signed by the "Médecin Traitant" or Ward Surgeon.

The French surgeons made a habit of keeping for their private records a copy of their dictation, and needless to say this habit also was gladly adopted by the American teams working with the French. A small notebook, carried in the pocket, furnished all the scraps of paper required; alternate pages were written on, and the intervening carbon copies were torn out and placed in the *pochette*. It is true that the Médecin-Chef had occasion once to complain that the carbon copies placed in the pochette were "presque illegibles," but it is believed this applied to copies furnished by one of the French teams, at a time when the supply of carbon paper had been nearly exhausted.

The points to be recorded on these scraps of paper were the following, and in the following order, as near as might be: The formation where the operation was done, the patient's name, rank, etc., the date and hour of injury, the date and hour of operation, the summary diagnosis, including the nature of the missile; the X-ray report (this was always repeated in condensed form under the description of the operation, in addition to the

original report furnished by the radiologist); a concise account of the operation and the condition of the wounded parts; the dressing of the wound; whether the patient was to be evacuated at once or to be held for further observation; and the means of his evacuation (*i.e.*, by hospital train, by motor ambulance to the nearest hospital centre; or, if a trivial injury, to the centre near the front where such patients were sent for recuperation before immediate return to the lines); and, at the end, the operator's name.

The autochir with which we were longest associated (Ambulance Chirurgicale Automobile No. 6, of which the Médecin-Chef was M. le Professeur Agrégé J. Guyot, of the University of Bordeaux) was situated in the outskirts of a village called Crève-Cœur-le-Grand, in Picardy, in back of Montdidier (and Cantigny), south of Amiens, and about 20 kilometres north of Beauvais, the nearest large town, which before the war had a population of about 20,000. The slightly wounded ("minima") were evacuated usually to Songeons, a town toward the west, in the intermediate zone ("Zone des Étapes"); but if the railroad happened to be cut by the German bombing expeditions, they were sent to Grandvilliers, nearer at hand; the severely wounded, including almost all the fractures, were sent by ambulance to Beauvais, which was a large hospital centre, and a flourishing one until the German bombing expeditions made life there, even in hospitals, rather precarious; while those patients who could travel to the interior of France were taken by ambulance to the H. O. E.¹ (Evacuation Hospital) about a kilo and a half distant on the Froissy road, and were there loaded on the Train Sanitaire.

Appended are a few typical records in Americanized French, from our service at Autochir 6, and some corresponding records, in Gallicized English from our service at Evacuation Hospital 6, U. S. A. (Souilly, south of Verdun). Explanations of the abbreviations are given in tabular form, for convenience of reference.

The United States Army did well to copy their Field Envelope and their Field Medical Card from the French; but in one essential point the American surgeons were inferior to the French in training: they did not know, and they had not been taught the important points which should be recorded. And the Field Medical Card was faulty in that it did not contain any place for recording the *hour of injury*. Space was provided for recording the hour *first aid* was given, but it is of no use to know the time of this unless it is known how long a period elapsed between injury and first aid. Moreover, experience has shown that "first aid" was very much less important as a factor in preventing infection of the wound than the first operation—excision, debridement, and extraction; and in the future it is the hour of injury, rather

¹ The formula H. O. E. is derived from the term Hôpital d' Evacuation, which in the early days of the war was abbreviated as Ho. E., and by the corruption of sign painters subsequently degenerated into H. O. E. At least this is the explanation given by the French themselves.

than that of first aid, which should be carefully recorded. The patient almost always knows approximately the hour of his injury, even though he may not know the day of the week or month, and these latter can be supplied by the surgeon. The American Field Medical Card is also troublesome because too long to fit snugly in the Field Envelope; and, being made of cardboard, it is impossible for the surgeon to take a carbon copy from it, if he makes his record directly upon it, as was evidently the intention, and as was the practice as long as the supply of Field Medical Cards lasted.

The habit of the American army in recording all war wounds as "gun-shot wounds" (G. S. W.), is another stumbling block to an accurate and terse statement of facts, unless it be considered of extreme importance (which it is not) to distinguish between these and the almost unknown bayonet or sabre wounds. The important point for record is the *nature of the missile*, and especially whether it was a shell fragment or a ball; the difference between a wound by a rifle ball and a machine gun bullet is negligible, except for medico-legal investigations, but the difference between a wound by a shell fragment and any kind of a bullet may mean the difference between gas gangrene and rapid healing, and this fact (nature of the missile) should always be recorded. Likewise the difference between wounds by shell fragments, grenade fragments, and fragments from aeroplane bombs, is negligible, except in a sentimental or historical sense. The habit of marking all these wounds merely as g. s. w. makes the surgeon in too many cases feel he is absolved from any further record. It is more satisfactory in every way, for the clinical history of the case, if the injury is recorded as "wound by ball" or "wound by shell fragment." It is worth while to note that wounds by "shrapnel" are quite rare, and that the term is carelessly and erroneously used as equivalent to shell fragment. It is also important to distinguish in the record between penetrating and perforating wounds: in the former the missile has lodged, in the latter it has passed all the way through. After this initial formula "Wound by shell fragment penetrating right thigh" or "Wound by ball perforating left forearm," should appear, in the summary diagnosis, the main complication, as "with fracture of femur, middle third," or "with section of ulnar nerve and artery above wrist."

Next should come a statement of the positions of the wounds of entrance and of exit, if the latter exist. If either wound is abnormally large and ragged it should be so stated. A concise and abbreviated description of the operation follows: In most cases it is sufficient to state "excision, débridement, extraction," as these terms denote definite and well-recognized procedures. If the foreign body is not found, this fact should be noted; or if it was so small as to be negligible and was not searched for, it should be so stated. If counterincision is made to facilitate extraction of the missile, or for the purposes of drainage, the fact should be noted. If arteries have been sectioned, the fact that they have been ligated should be a part of the history; or if a nerve has been injured its condition (contused, or sectioned)

RECORDING SURGICAL OPERATIONS AT THE FRONT

and the treatment adopted should be indicated. In cases of fracture the treatment of the fragments should be recorded, especially whether or not fragments have been removed, and the extent of the esquillectomy (large, medium, or parcimonious). The antiseptic employed also should be noted. It is sufficient to record it very summarily—as iodine, Dakin, Mencièrè. The method of drainage (tube or wick), the dressings and splints should form a part of the record.

Now to get all these facts in the record requires not only systematic dictation, but it requires a clerk with a reasonable knowledge of surgical terms, a good general education, and above all a good handwriting, and speed and accuracy. It is important to get through with as many operations hourly as is humanly possible. To demand this clerical work of the anæsthetist or of one of the surgical team needlessly delays the commencement of the next operation. The French reckoned that the utmost speed conceivable would not permit the surgeons to average more than four patients in an hour, and they were quite well satisfied when a speed of three hourly was maintained. This requires not only that the patients be supplied to the operating room at that speed (which demands machine-like working of the triage, the preparation rooms, the sterilizing plant, and the fluoroscopic examinations), but it requires also that the patients leave the operating room at the same speed. While we were with the French it was possible at most times to maintain this average (three patients an hour, or about 24 patients in the eight-hour period of operating), with the aid of the clerks they supplied and the wonderful coördination maintained in the accessory services mentioned above. But with the American army we never could average more than two patients hourly except for very short periods at a time.

I would recommend, therefore, that before the next war the following modifications of the methods now in use of recording surgical operations at the front be adopted:

1. A field card of thin, tough, non-bibulous paper, of a size to fit easily inside the field envelope.
2. A space on the field card for recording the time of injury.
3. The records to be made in indelible pencil, and the surgeon encouraged to keep for his personal use a carbon copy of the records.
4. The abolition of the cumbersome term "gunshot wound" and the substitution for it of the term "wound by shell fragment (or ball, or grenade fragment, or shrapnel, or airplane bomb, etc.)."
5. The adoption of the French terms "Orifice of Entry" and "Orifice of Sortie," abbreviated as O. E. and O. S., as more terse than "Wound of Entrance" and "Wound of Exit" which cannot be so intelligibly abbreviated.
6. The provision of trained clerks for recording the surgeon's dictation. These clerks could be trained under the auspices of the Red Cross and would prove a valuable addition to the surgical teams for work in the advanced area.

EXAMPLES OF OPERATIONS RECORDED IN FRENCH

A.C.A.6.

Peruy, Charles, Cpl. 49 Inf., Cie. 3

Bl. 8. 6. 18, 12 h.

Op. 8. 6. 18, 1 1/2 h.

Plaies multiples par E. O.

Radiog.: Bras g.: petit éclat superf., face ext.

Main g.: plusieurs tres petites éclats.

Cuisse g.: éclat face int. du femur niveau trochanter minor.

Région lombaire et pied g., neg.

1. Excis. et débrid. d'un plaie region lombaire g., hematome; projectile non trouvé; excision d'un bouillie des muscles lombaires. Mèches iode.

2. Débrid. O. E. niveau troch. major face post. Fracture découpée de la troch. minor. Extraction d'un projectile tranchant. Drain et mèches iode.

3. Débr. O.E. et S. region malleolaire post. g. Trajet a passé en avant du tendon d'Achille et il y a section de l'artere et veins tib. post. Ligaturcs. Nerf intact. Mèches de part en part, iode.

4. Débr. et extr. d'un projectile de la muscle triceps au dessus du condyle ext. de l'humerus g. Mèch iode.

5. Nettoyage de la main.

A Garder.

A. C. A. 6.

Hoffman, Carl, Soldat, 1e. Eug., U. S. Army.

Bl. 28. 4. 18, 12 h.

Op. 29. 4. 18, 17 h.

Plaie pcutrante epaule gauche par E. O. O. E. 2.5 cm. en avant de l'acromion.

Radio: Petit projectile (grosse tête d'épingle) repère à 3 cm. de profondeur (bras le long du corps). Ce projectile se profile entre l'acromion et la tête humerale, au contact de la tête, probablement intra-articulaire.

Incision, extraction du projectile sous l'ecran, logé dans la capsule au dehors du tendon bicipitalc. Suture des muscles et de la peau.

Evacuer, T. S. Crèvecoeur.

A. C. A. 6.

Naouar, Oub Abder Kadcr, 2c. Cl., 7e Tir.

Bl. 26. 4. 18

Op. 27. 4. 18, 22 h.

Plaie perforante cuisse gauche par balle, entré en avant, sortie posterieure en dehors du femur.

Débridement, excision large. Drain de part en part. Mencièr.

Plaie en seton region lombaire gauche.

Débr., excis., Mencièr.

A Garder.

A. C. A. 6.

Hains, Theodor, 34e. Inf. Allemand.

Bl. 9. 6. 18, à nuit

Op. 13. 6. 18, 14 1/2 h.

Plaies penetrantes, crâne, épaule et bras g., par E. O. Les plaies de la tête et du creux axillaire g. sont infestées par des vers.

1. Plaie pen, pli post. de l'aiselle g. Exc., débr., extr., du projectile par contreouverture au pli anterieur de d'aiselle. Drain de part en part.

RECORDING SURGICAL OPERATIONS AT THE FRONT

2. Seton du bras g. Excis. Mèche de part en part.
 3. Grande plaie du cuir chevalu, region parietale gauche. Excision, extraction du projectile fixé dans le crâne. Autoplastie du cuir chevalu.
 4. Éclatement oeil g. Enucleation et esq., fracture orbitale.
 5. Plusieurs plaies superficielles de la face g., excision et sutures.
- A Garder.

EXAMPLES OF OPERATIONS RECORDED IN ENGLISH

E. H. 6.

Switzer, Joseph, 61st Inf., Co. C.

Wd. 10. 12. 18, 6 h.

Op. 10. 12. 18, 19 h.

Wd. by ball entering outer face l. thigh, leaving inner face l. thigh, middle $\frac{1}{3}$, traversing penis with rupture of corpus cavernosum and laceration of foreskin, then causing tangential wd. r. thigh.

X-ray neg.

Op. ether. Nett. of wds. Suture of penis. Iodin.

Evacuate.

E. H. 6.

Ricotte, Antonio, 61st Inf., Co. F.

Wd. 10. 16. 18, 18 h.

Op. 10. 17. 18, 17 $\frac{1}{4}$ h.

Wd. by S. F. perforating face and skull, with F. C. C. rt. mastoid region. Patient has been in shock ward since admission. Has cerebral symptoms, some rigidity of neck. Rt. eye marked exophthalmos. Punctured wd. to left of root nose. Brain oozing from external auditory meatus. Missile probably entered at nose and made its exit through mastoid. X-ray neg.

Op. Ether. Excision of scalp wd., of prolapsed brain, and of all depressed and soiled fragments of bone. Complete closure of scalp by autoplasty. Iodin.

Hold.

E. H. 6.

Carden, Stanley, 316th Inf., Co. C.

Wd. 10. 11. 18, 13 h.

Op. 10. 13. 18, 2h.

Wd. by S. F. penetrating rt. buttock.

X-ray, buttock: F. B. 20x15 mm., 70 mm. deep.

Op., ether. Debr. and extr. from beneath sciatic nerve. Persistent bleeding from branch of gluteal artery controlled with great difficulty by suture and ligature. Tube. Iodin.

Evacuate.

E. H. 6.

Clavridge, Gilford, 39th Inf., Co. K.

Wd. 10. 10. 18, 6 h.

Op. 10. 10. 18, 21 h.

1. Wd. by S. F. perforating rt. leg, with fracture of tibia and fibula.

2. Wd. by S. F. penetrating calf rt. leg.

3. Wd. by S. F. tangential, left calf, lower $\frac{1}{3}$.

X-ray: fracture of leg, F. B. 10x15 mm., 40 mm. deep.

Op., ether: 1) O. E. ant. face middle $\frac{1}{3}$. O. S. through Tendo Achillis. Debr., Esq. parc. 2) Extr. of S. F. from wd. of calf. Cabot splint by Lt. Moore. 3) Nettoyage.

Nom	Prénoms	Grade	Corps, Compagnie, etc.			
Diagnostique sommaire						
Ci-dessous, souligner au crayon de couleur les mentions utiles						
Blessé le.....	Transportable	assis à couché	Catég. spéciales			
Injections antitétan.				ire { faite le..... à faire.....	à { courte distance zone des étapes interieur	{ Officier Allié Musulman Indigène Ennemi
(Opération importante)						
.....faite le.....	Services Destinataires	A.—Chirurgie générale: <i>grands blessés ou soins op.</i>				
Soins à donner en cours de route		B.—Chirurgie générale: <i>petits blessés ou soins non op.</i>				
Régime.....		C.—Chir. spéc. <i>Maxillo-faciale.</i>				
à sonder		D.—Chir. spéc. <i>Urinaire.</i>				
Pansment { faite le.... à faire le..		E.—Chir. spéc. <i>Orthopédie.</i>				
		F.—Chir. spéc. <i>Syst. nerveux.</i>				
		G.—Chir. spéc. <i>Ophthalmologie.</i>				
		H.—Chir. spéc. <i>Oto. rhino-lar.</i>				
		I.— <i>Prothèse dentaire.</i>				
		K.— <i>Physio ou Mécanotherapie.</i>				
		Z.— <i>Eclopés ou petits malades (zones des étapes)</i>				
		L.— <i>Médecine générale.</i>				
		M.— <i>Méd. spéc. contagiou</i>				
		N.— <i>Méd. spéc. Vénériens</i>				
		O.— <i>Méd. spéc. Aff. cut.</i>				
		P.— <i>Méd. spéc. Psychiat.</i>				
		R.— <i>Méd. spéc. Aff. nerv</i>				
		S.— <i>Hôpital sanitaire.</i>				
		T.— <i>Convalescents.</i>				

FIG. 1.—The "Pochette" or French Field Medical Card.

Name	Unit
Rank	Unit
CAN WALK	SLIGHT
Litter Case	SEVERE
(Strike out words not applicable)	
DIAGNOSIS (briefly)	
(Special attention needed in transit)	
Ambulance Label	
Ambulance Train (Motor) No.	
Date	Hour
Destination	
Arrival, Date	Hour
Hospital Train Label	
Hospital Train No.	
Date	Hour
Destination	
Arrival, Date	Hour
NOTE.—To be SECURELY tied on patient's clothing over breast. To contain field medical records, and other papers relative to patient.	

FIG. 2.—Face of U. S. Field Envelope.

RECORDING SURGICAL OPERATIONS AT THE FRONT

APPROVED ABBREVIATIONS

MorphiaM.
 Anti-Tetanic SerumA.T.S.
 Gunshot WoundG.S.W.
 Fracture, SimpleF.S.
 Fracture, CompoundF.C.
 Fracture, Compound, Comminuted.F.C.C.
 Not yet diagnosed or
 UndeterminedN.Y.D
 Fever of Unknown OriginF.U.O.
 Disordered Action of HeartD.A.H.
 SlightO.
 SevereS.

FIELD MEDICAL CARD

Name
 (Block letters)
 RankNo.
 Regiment or Staff CorpsCo....

Sick Wounded
 Line of Duty—Yes or No
 (Strike out descriptions which do not
 apply)

Field Hosp. No. Evac. Hosp. No.
 Dressing Station No... Camp Hosp. No...
 Date of Admission
 Morphia
 Dose and Time
 A. T. Serum
 Dose and Date
 Diagnosis

Base Hospital No.
 Diagnosis (if altered from above)

Base Hospital No.
 Diagnosis (if altered from above)

FIG. 3.—Outside of U. S. Army "Field Medical Card" (adopted from the French "Billet d'Hôpital de Coupons") to be folded in three and carried in Field Envelope.

Date of entry and medical unit receiving patient must Brief Clinical Notes
 be recorded immediately on admission and signed by 'M. O.

Field	}	Base Hospital No.	Base Hospital No.
Evacuation		Hospital No....	Date of Entry Date of Entry
Camp			
Date of Entry			

This card must accompany the patient, attached to his clothing. It must not be destroyed. It will be transmitted with the patient if he is evacuated to the U. S. Temperature charts or additional clinical notes may be sent with this card in the same envelope.

FIG. 4.—Reverse of U. S. Army Field Medical Card.

ABBREVIATIONS OF FRENCH TERMS

A.C.A. = Ambulance Chirurgicale Automobile ("Autochir")
 Abs. = Abstention (no operation done)
 Bl. = Blessé (wounded)
 Debr. = Debridement

ASTLEY P. C. ASHHURST

- E.O. = Eclat d'Obus (shell fragment)
Esq. = Esquillectomie (removal of bone fragments, as distinguished from sequestromy, which is removal of sequestra)
Ev. = Evacuer (to evacuate)
Exc. = Excision
Extr. = Extraction
H.O.E. = Hopital d'Evacuation
Nett. = Nettoyage (mechanical cleansing)
O.E. = Orifice d'Entrée (wound of entrance)
O.S. = Orifice de Sortie (wound of exit)
Seton = Superficial perforating wound, not extending beneath deep fascia
T.S. = Train Sanitaire (hospital train)

ABBREVIATIONS OF ENGLISH TERMS, INCLUDING THOSE RECOMMENDED FOR
ADOPTION FROM THE FRENCH

- Abs. = Abstention, *i.e.*, examined, and no operation deemed advisable
Debr. = Debridement, wide opening of wound to make all parts easily accessible
A.T.S. = Antitetanic serum
Esq. = Esquillectomy, removal of bone fragments
Ev. = Evacuate
Exc. = Excision
Extr. = Extraction
F.S. = Fracture, simple
F.C.C. = Fracture, compound, comminuted
M. = Morphin
Nett. = Nettoyage, mechanical cleansing
O.E. = Orifice of entry
O.S. = Orifice of sortie
S.F. = Shell fragment
Ball = Machine-gun or rifle bullet

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held May 5, 1919

DR. GEORGE G. ROSS, Acting President, in the Chair

RECOVERY AFTER OPERATION FOR TRAUMATIC LACERATION OF THE LIVER.

DR. JOHN B. ROBERTS presented a little girl about seven or eight years old who had rupture of the liver the result of an automobile accident which occurred about the middle of February. The child was sitting on the curb when the automobile struck her on the legs throwing her on her abdomen upon the pavement. She was brought into the Polyclinic Hospital suffering great pain in the upper abdomen. Percussion showed that there was fluid in the abdominal cavity. Upon opening the belly he found a tongue-shaped flap about $2\frac{1}{2}$ inches long and $1\frac{1}{2}$ inches wide had been torn off from the lower surface of the liver near the gall-bladder. The pedicle was posterior. There was blood in the abdominal cavity, the retroperitoneal space and in the layers of the gastrohepatic omentum. By turning the flap up and pressing a thumb upon it, it was held in place and the bleeding was checked. He put against the replaced liver tissue a packing of two yards of bandage $1\frac{1}{2}$ inches wide. This he held in place by an old-fashioned glass drainage tube with its bell-shaped outer end against the packing and brought the end of the tube obliquely through the abdominal wall. The child was in the hospital for about two months and has now been out for two weeks. There will probably be a hernia where the packing was allowed to extend outwards. It was gradually removed in about three weeks. He presented the case because traumatic rupture of the liver with operative recovery is rather unusual. The fortunate result was due to getting the abdomen opened promptly and the torn piece of liver replaced before a large amount of bleeding had occurred. He reported some years ago to the College of Physicians of this city a case in which he lost a patient after traumatic rupture of one of the hepatic veins upon which he had operated.

DR. GEORGE G. ROSS said that he had had two cases of rupture of the liver from traumatism. Both were ruptures of the right lobe and both were treated by packing, without attempting to suture. The first case recovered after a stormy convalescence. In the second case after the rent had been successfully packed it was reported that one piece of gauze was missing. In order to account for this it was necessary to search the abdominal cavity and in so doing the gauze which had been packed into

the rent of the liver was displaced and before it could be put back the man bled to death on the table. In rupture of the liver with excessive hemorrhage and shock, a minimum amount of surgery is all that should be attempted. In three cases in which there was rupture of the spleen, instead of taking the spleen out, he used packing, with recovery in all three cases. In a case seen recently the patient was wrestling with another boy weighing 200 pounds who fell across his abdomen, causing a rupture of the spleen. The abdomen was opened by a left rectus incision and the rent in the spleen felt. Packing was inserted and the boy put to bed. He reported four or five months afterward apparently in perfect health.

A CHILD WITH DOUBLE CLEFT OF LIP AND PALATE, PROTRUSION OF THE INTERMAXILLARY PORTION OF THE UPPER JAW AND IMPERFECT DEVELOPMENT OF THE BONES OF THE FOUR EXTREMITIES.

DR. JOHN B. ROBERTS showed an infant of Italian parentage, belonging to a family in which there was a good deal of intermarrying. The parents of this child are first cousins. There are two living children, one eleven years; one, three, both girls. The first child, born in Italy, was a monstrosity and is dead. The two next children are normal in development. Three years ago a girl was born almost identical in deformities with this male child shown the Academy. The girl just mentioned died shortly after birth and this boy will probably not survive many days. He is now about a week old. (NOTE.—The child did die when fifteen days old.)

The X-ray pictures taken show that the femurs were quite well developed, but the bones of the leg proper on both sides are almost absent. The bones of the arm are apparently absent, though both upper extremities have the radius and ulna. The photographs accompanying this report show the peculiarity of the child better than any description that can be given in a short communication. Doctor Roberts expects to deposit the infant in the Mütter Museum. There is now in the Anatomical Laboratory of the Polyclinic Hospital the preserved body of the sister, born three years ago, belonging to Dr. Addinell Hewson's collection. The two children are almost identical in appearance, and the sister died when only a few days old as has previously been reported.

THE METHOD OF RECORDING SURGICAL OPERATIONS AT THE FRONT

DR. ASTLEY P. C. ASHHURST read a paper with the above title, for which see page 241.

DR. THOMAS F. MULLEN, Major U. S. A., of Pocatello, Idaho, said that he had had some experience with French and American records and he was absolutely in accord with what Colonel Ashhurst had said about the



FIG. 1.—Louis M. Case of cleft palate and other congenital deformities of bones.



FIG. 2.—Same patient as Fig. 1, one week old.

1

2

3

4

5

completeness and the good appearance of the French cards. The American cards are usually written in pencil which is apt to be rubbed off and the cardboard breaks easily. It is interesting to hear what happens to the cards after reaching Washington, because in the midst of their work they received a general order that the surgeon in charge of the service must personally see that all field cards were kept, giving diagnosis, clinical, operative and final notes. Before leaving Paris an attempt to do that was made. Colonel Hutchins made very complete records, at his own expense in employing stenographers. In some instances he detailed their own clerks, but the records made in the operating room by the anæsthetist or assistant operator necessarily often proved unsatisfactory. The French record card was very good because it needed only a check or underscoring of one of the printed forms accompanying it. Usually they were enclosed in their envelopes and not apt to get lost. Often the American cards did not belong to the soldier of whose case they were supposed to be a record.

DR. CHARLES F. MITCHELL said that the British field card is a much smaller card than the French with four sides and is pretty much the same as Doctor Ashhurst described. It gives the name of the patient, when he was injured and other data, and is very satisfactory in every way. If an X-ray had been taken at the field ambulance or casualty clearing station all the data were on the card. If a case remained for some time at the field hospital some extra temperature charts accompanied the card. It seemed to him a great advantage to have everything on one card rather than to have a lot of papers with the card. It was a simple matter to make these memoranda and while working at the casualty clearing station Doctor Packard was with him, and while sewing up a wound he would take the notes dictated to him. He never felt that they needed a clerk. As a matter of fact, their quarters were so small that they would not have had room for more people. The English card is really the ideal one.

DR. EDWARD B. HODGE said that he felt a good deal as did Doctor Mitchell. The French card looks like a good one, but he would prefer the British. An advantage of the British card was that it did not have loose slips of paper which could be easily lost. He never worked with the French but he could appreciate their thoroughness. Most of the trouble, in his opinion, was due to inexperience of operating teams. The British card is complete and thorough and, when well worked, went through in good style. All that was needed was there and, like everything else, when properly worked, gave good results.

DR. GEORGE G. ROSS asked Doctor Ashhurst whether he had seen the German field record card, which is made of material something like linen paper and is difficult to tear and has a series of perforations by which certain portions of the edges can be detached. There were five or six different headings, giving time of injury, character of wound, when first

aid treatment was given and whether operation had been performed. For simplicity and general outline of what had been done the card seemed to him nearer the ideal than any other seen. He happened to get one from a wounded German who was brought into the field hospital where he was working. Probably Doctor Ashhurst's approval of the French card may be due to the fact that he was able to read, talk and live French, which many others could not do. He asked whether about the time of the 18th and 19th of July at Soissons, when the men were coming back by the hundreds and the surgeons were working from twelve to thirty-six hours, they could be held morally responsible for not keeping accurate records.

At Field Hospital No. 12 there were three teams to start with, later increased to seven. There were three tables and one scribe to take all the notes dictated by the surgeons and the assistants. During six days 3500 patients passed through this unit. The notes were taken with pencil in bad handwriting and no doubt worse English. Copies were made of the data so that after all most of the material was preserved. In certain times of stress it was not possible to do this.

BOOK REVIEW

SURGICAL TREATMENT. A Practical Treatise on the Therapy of Surgical Diseases for the Use of Practitioners and Students of Surgery. By JAMES PETER WARBASSE, M.D. In three large octavo volumes. Volume III, 861 pages with 864 illustrations. Philadelphia and London. W. B. Saunders Company. 1919.

The first two volumes of this book of Warbasse have already received review (see *ANNALS OF SURGERY*, lxviii, 446, and lxix, 222). The present volume completes the treatise. It is supplemented by a complete index to the three volumes in a separate convenient volume of 123 pages. Such an index to so comprehensive and extensive a work is of as great importance to the practical usability of a book as a knob is to a door. It opens the book for ready reference. To have the general index furnished to us, as Doctor Warbasse has done, as a separate book, easily handled and readily referred to, is a most commendable and attractive novelty in book-making.

The preparation of such a comprehensive treatise by a single author is an unusual achievement in these days of coöperative authorship, and of the production of systems which are a series of monographs by many authors.

It is altogether more noticeable and interesting since the author has been conspicuously an advocate of the coöperative principle in other forms of human activity. He has certainly presented a strong demonstration of the fallacy of his own reasoning in other fields in the excellence and value of these three great volumes, produced by his single authorship, in which he has embodied the results of his own studies and labors through thirty years of devotion to surgery, for they are the more valuable as they have running through every chapter the same restraining, guiding, conservative, experienced, judicious mind.

We are glad Doctor Warbasse has given us this book. As we have it we feel as if we could always appeal to "Philip sober" whenever we find that its author, branching out into other fields, is betrayed into fallacies, possibly mischievous; in this book we have the "swan song" of the author as a surgeon; it is a thesis with which he has bidden farewell to surgery, henceforth to devote his time and energies to other lines of effort. It seems a pity that this should be so, but it is doubtless the result of the application to his own life of those principles of surgical economics which he has presented in the closing pages of this treatise. According as we have been able to gather the drift of the author's reasoning, he would have it that "individualism" is the bane of surgical life, as well as of the social state in general. Truly a revolution-

BOOK REVIEW

ary doctrine in this Western Hemisphere, where all the philosophy of its civilization and of its development to this day has had as its basis the proclamation of the rights of man as an individual to life, liberty, and the pursuit of happiness!

However this may be we are sorry to lose from the list of practical surgeons the author of so notable a work as these three noble volumes. It is to be regretted that at the time when by his age, his undiminished vigor, his accumulated experience, and ripeness of judgment he could have filled in the world an important and most useful place in this special field, in which he had shown such aptitude and demonstrated such skill, he should have abandoned a field in which this book shows him to have become a master. In this last volume the field of surgery is swept up to gather in the subjects remaining from the two first volumes, beginning with Hernia and ending with "The Economics of Surgical Treatment," and including The Surgery of the Extremities, that of the Genito-Urinary Organs, male and female, and Plastic Surgery. This volume preserves the same characteristics as were noted in the earlier ones: clearness of treatment, positiveness of statement, vigorous diction. The work, as a whole, may be accepted as a faithful mirror and a trustworthy guide in the field of surgical treatment as developed to date.

LEWIS S. PILCHER.

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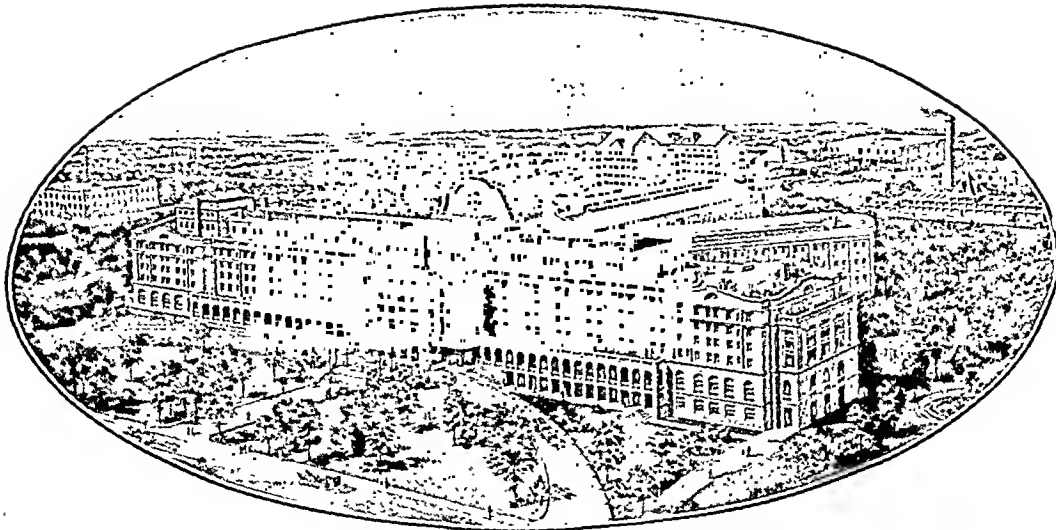
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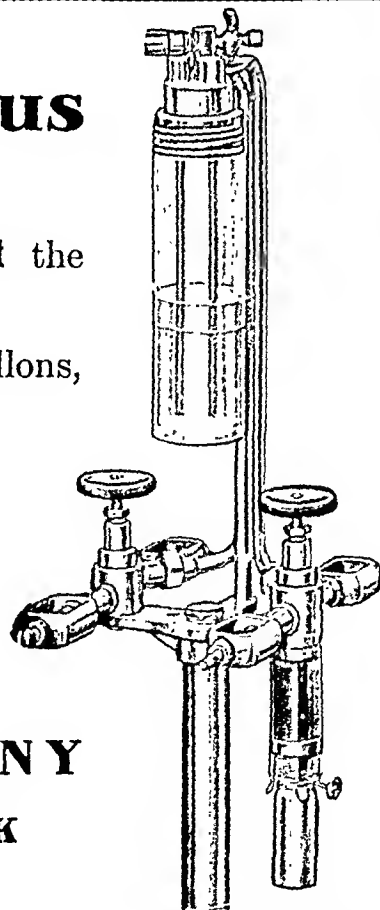
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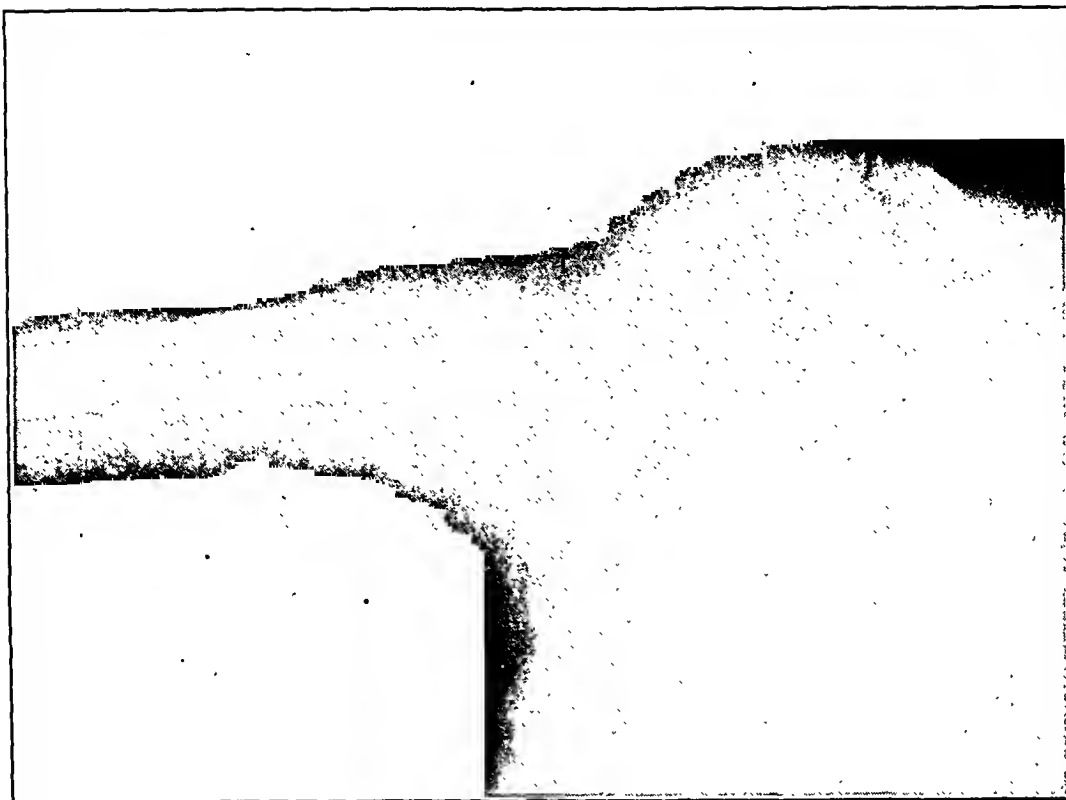
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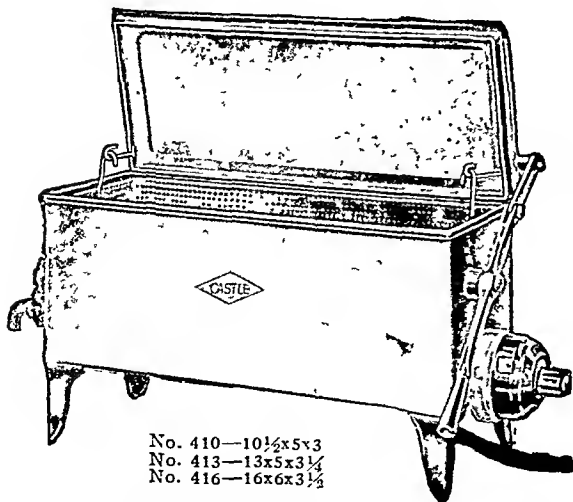
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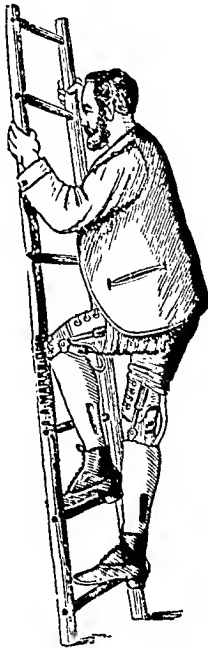
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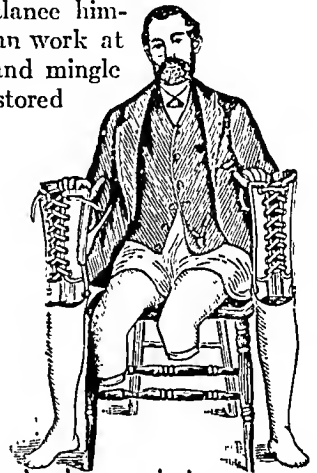
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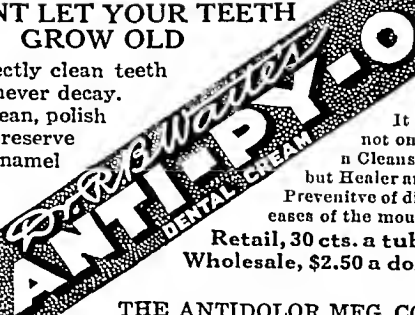
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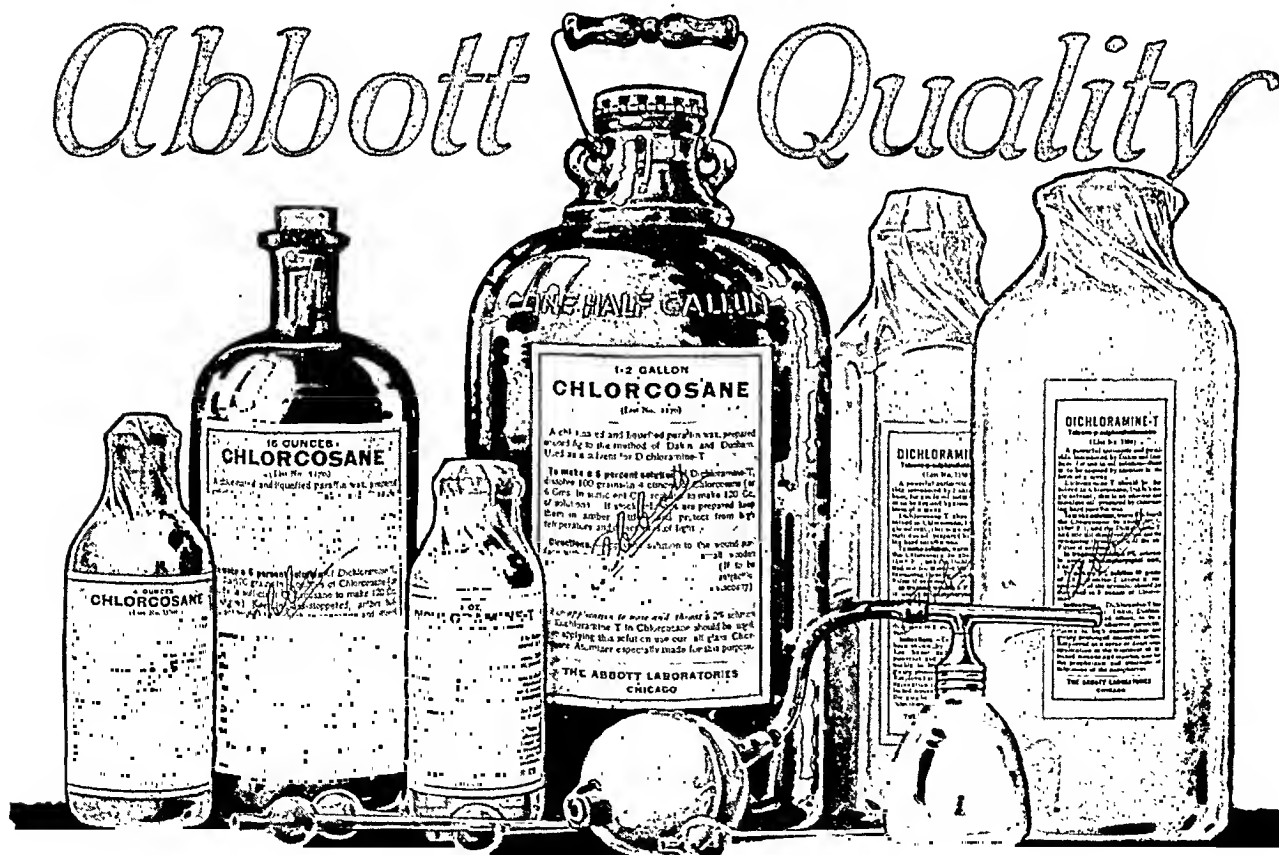
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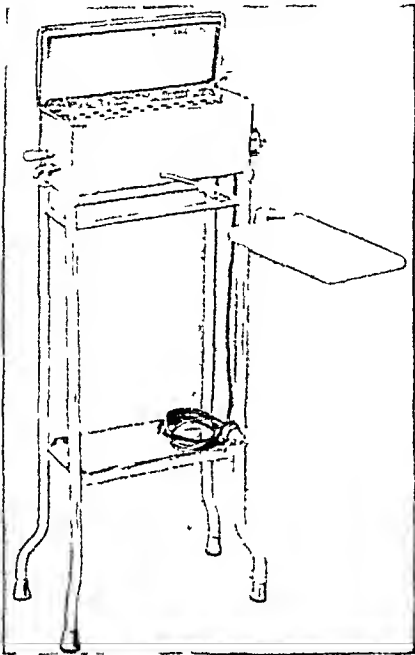
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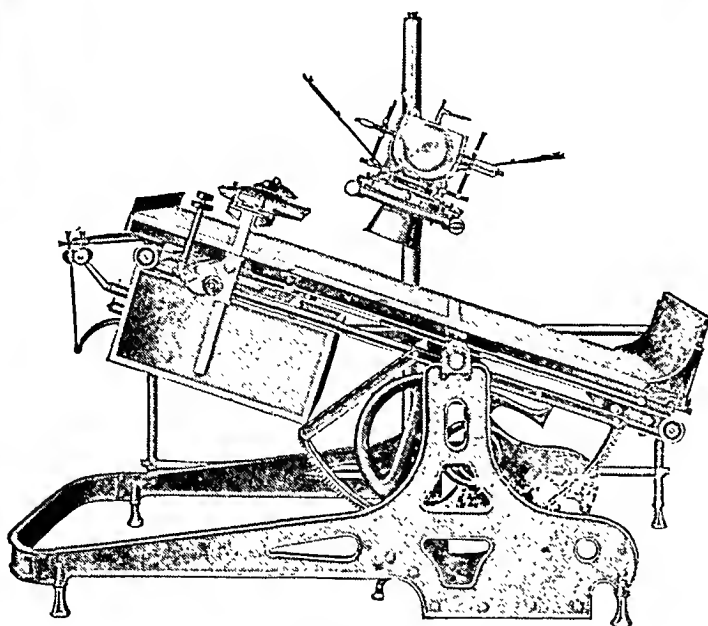
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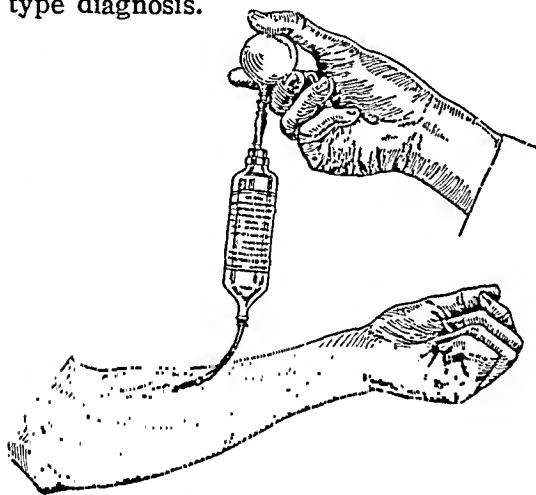
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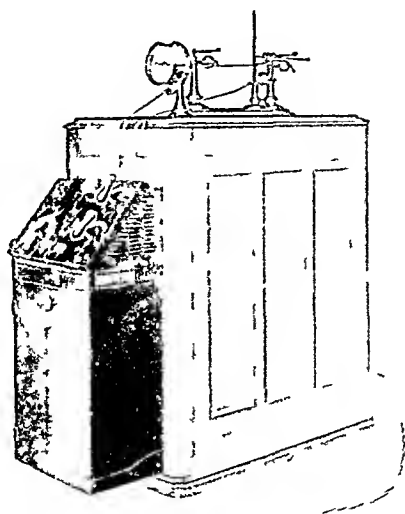


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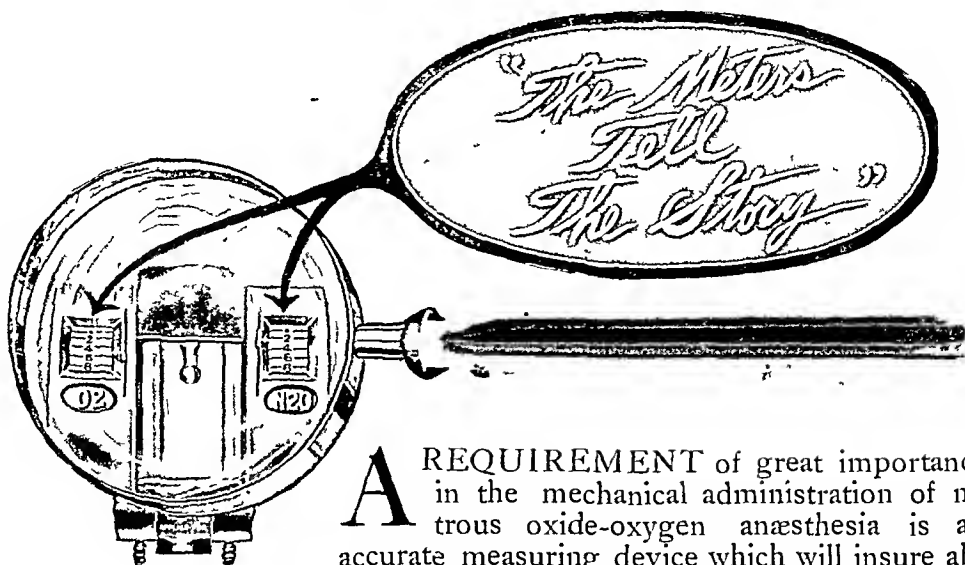
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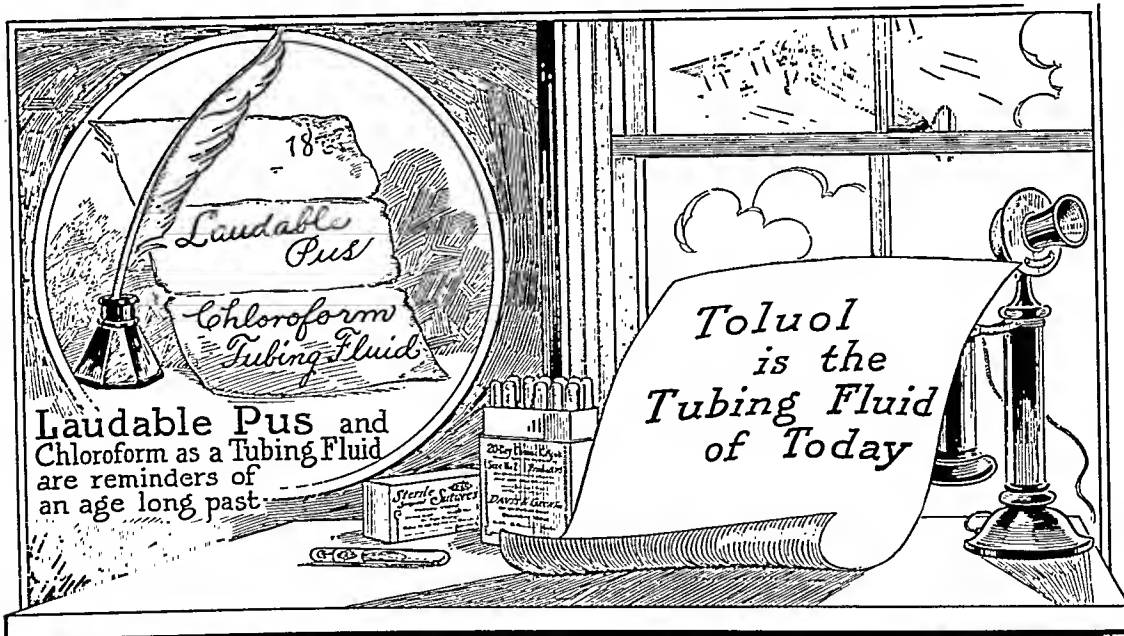
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ANNALS *of* SURGERY

VOL. LXX

OCTOBER, 1919

No. 4

THE MOST IMPORTANT FACTOR IN THE TREATMENT OF WAR WOUNDS AND THE MOST IMPORTANT FACTOR IN CIVILIAN SURGERY—THE GOOD SURGEON*

BY GEORGE W. CRILE, M.D.

OF CLEVELAND, OHIO

THE surgeons and the pathologists who for four years have intensively studied war wounds have formulated many theories of treatment—many apparently contradictory theories. Thus, there have been presented the claims of the value of various chemical agents against those of no chemical agent; of moist dressings against dry; of heat against cold; of frequent dressings against infrequent, and of no dressings against both; of sunlight and of electric light against occlusions; of immersion against hot air; of bacteriological control against clinical judgment; of vaccine toxins and foreign proteins against normal reaction; of wound inoculation with harmless organisms against wound sterilization; of isotonic against hypertonic solutions; paste has competed with paste; bipp with ip; sap with both; and chromic paste with all.

Does not this intensive study of infection in war wounds for this comparatively short period equal and recapitulate the more leisurely study of infection during the thirty years since Lister first proposed the carbolic spray? And is there not slowly emerging from the present conflict of opinions the same fact as that which emerged from the post-Listerian period—that the one agent of successful surgery, whether war surgery or civil surgery, is *the good surgeon*?

In civil surgery here in America, by what agency was mastery achieved over appendicitis, over cholecystitis, over tubal infection, over adenitis? What agent has contributed the most to the success of resection of the intestines and of the stomach; of gastro-enterostomy; of treatment of suppurating stone in the kidney; of treatment of infection of subcutaneous tissue? What agencies have achieved survival? One and but one—*the sound surgeon*, who always creates opportunity. Is it possible that in these four intense years of war surgery, in which more experience in traumatic surgery has been accumulated than during the past thirty years, we have traveled around the same circle as in civil surgery and have again found the same *surgeon*?

* Read before the American Surgical Association, June 16, 1919.

By sound surgery we mean the assumption of complete inclusive responsibility for every item that enters into the result; the consideration of the wound as well as the patient; the development of an ability to read the wound as well as the man aright. Sound surgery means quick, innocuous, timely intervention; it means seeing clearly the to-morrow of the wound; it means no intervention unless there is to be a net gain; it means a sharp knife, a good anæsthetic, a painless innocuous dressing; it means as much respect for the tissues of the anæsthetized man as those of the unanæsthetized man; it means a training in judgment that unerringly tells when to cut, how far to cut, when to quit cutting. It plays all the defenses and reparative forces of the patient. Good surgery is the exponent of no single method. It recognizes the anatomical and environmental situations in which chemical and physical agencies are useful. Good surgery exploits physiologic rest and fluids and sleep; it gives little pain. Good surgery evokes confidence; and confidence begets rest; and rest begets restoration. Good surgery, then, makes use of antiseptics and physical forces, just as it uses incision, counter-drainage, revisions, skin-grafting, blood-transfusion. Good surgery does not substitute an easy formula for its principles; above all, it always is dissatisfied with its work and always is open to suggestion.

What could the good surgeon accomplish with the wounds of war, with good opportunity but no antiseptics? Without antiseptics he could close by primary union a higher percentage of contaminated wounds than with antiseptics; he was able to remove damaged tissue with such accuracy that the natural defenses of the revised wound became its best antiseptic; he closed penetrated knee-joints more securely without than with antiseptics; he closed penetrated skulls without better than with antiseptics; he operated on perforated intestines more successfully without than with antiseptics; he cleared up foul and infected superficial wounds as well without as with antiseptics; he met gas gangrene with the timely use of the knife as well without as with chemical agents. He closed healthy superficial wounds with early suture tied lightly; healthy wounds that could not be closed by suture he closed by skin grafting, both as a healing and as a bacteriological policy; he closed fæcal and urinary fistulæ without antiseptics.

On the other hand, he realized equally that in compound fractures with or without bone infection, in deep, recessed wounds, in pyocyaneus infection in many other types of wound, that antiseptics might have great advantages, and he used them and used them well. In certain phases of a wound, he would use Carrel-Dakin; in another, acetic acid; in another, hot pack; in another, incision—a physiologic incision to-day to avoid the tissue tension of to-morrow; in another, transfusion; in another, sunlight or electric light; in another, continuous alcohol to make a scar covering.

In the rush of a great battle, he incised for drainage, and in addition he made "physiologic incision" to avoid the tension that is sure to follow the next day from the inevitable infection.

But in quiet times, with microscopic exactness, he dissected out every atom of devitalized tissue. He read accurately not only the wound, but the patient; not only the patient, but the military situation; not only the military situation, but the condition of the infecting soil, the state of transport, his surgical assistance, and the type of nursing care—that is, he weighed accurately his chances for success. Therefore, the army medical service and the wounded man pinned their hope and their faith first, last, and always to the one agency of wound treatment that in civilian surgery emerged clearly from the confusion of the Listerian period; emerged clearly from the confusion of the four years of military surgery—*the sane, sound surgeon*.

THE PROBLEM OF THE "SLIGHTLY WOUNDED" IN MILITARY AND CIVILIAN PRACTICE *

BY WILLIAM E. LOWER, M.D.
OF CLEVELAND, OHIO

EVERYONE who has had the high privilege of participating in the World War must now be deeply concerned with a consideration of the way in which the lessons acquired in that vast experience may be adapted to the needs of civilian life. For the medical officers in particular the war has supplied a post-graduate course of untold value in organization, in transportation, in sanitation, in hospital construction, in the management of supplies, in the treatment of every variety and kind of wound by every variety of method, and—perhaps most important of all—in noting what *not* to do.

Among the infinite problems met by the medical officer in his experience both at the Front and at the Base Hospital, one of the most pressing was that presented by the slightly wounded man—the "walking wounded."

In rush periods, when large numbers of seriously wounded cases demanded the immediate attention of the medical officers and attendants, there was an inevitable tendency to neglect the still larger number of slightly wounded, or at the best to leave them to the attention of the comparatively untrained man, the most expert judgment being engaged with the apparently more urgent problems of the more serious cases.

This seemingly unavoidable neglect of the slightly wounded proved to be a dangerous hazard to the available man power and rapidly thinned the front line in certain periods of the war. The seriously wounded could be of no further service in the trenches, and it became of the greatest strategic importance that the slightly wounded should be returned to the line in the shortest possible time. Yet because of the pressure of numbers and the lack of early expert care, thousands of men with slight injuries became seriously infected and many died or were permanently disabled. The time factor in these cases was of supreme importance, and cases which under proper care could have been returned to the line within three weeks, were disabled for three months or more.

While it is true that the results of neglect of the "slightly wounded" in civilian practice cannot be computed on so gigantic a scale, nevertheless if all cases of apparently trivial industrial accidents which become infected as the result either of neglect on the part of the patient to report promptly or because of inefficient treatment, could be paraded annually, the size of this army of civilian disabled would be startling in the extreme. As they cannot be thus displayed and only isolated cases are noted no special impression has

* Read before the American Surgical Association, June 16, 1919.

been made, and the consequent loss of life and limb and the economic loss to the community go on unchecked.

This is more true of the smaller than of the larger industrial centres, for the larger industries appreciate the value of the time loss of their employees and are constantly striving for a more efficient medical organization. Many of the great industrial plants have splendidly equipped medical departments under able advisors in which thousands of cases are treated annually. As a result, these plants report an extremely small per cent. of cases of infection which come from minor injuries. The greater number of casualties among the industrial wounded occur in the smaller centres, where there is no organized plan to provide proper care or where the surgical attendance is given by men of limited experience.

What may be accomplished by proper organization is well illustrated by the reports of Doctor Sherman, Chief Surgeon of the Carnegie Steel Company, who states in a recent letter :

The percentage of slight wounds which go on to serious involvement is almost nil where the patients report within a reasonable length of time for first-aid treatment at our emergency hospitals. Before these hospitals were properly organized and equipped, the percentage of infection varied considerably; at none of our plants was there less than 5 per cent. of the open wounds infected, while in some the percentage ran as high as 50. The reason for this was faulty organization and carelessness on the part of doctors and nurses. As a result of our campaign of education among our employees to report immediately for all minor accidents regardless of their nature, we have had very few serious involvements which have been due to accident. We have found that the ratio of infection where the patients received early first aid average 1 to 700. The vast majority of our cases that are infected come to us infected as a result of delay in reporting.

We occasionally have palmar abscesses, infections of the fingers, and sometimes a little lymphangitis of the extremities as a result of delay, but it is extremely rare that we see cases of amputation of legs or arms which are the result of insufficient early treatment. The reason for this is we have absolute control of all cases just as soon as they are injured, and have a competent corps of doctors and nurses and immediate attendance.

Investigation of this subject will reveal the fact that much of the infection is due to lack of coöperation of the large industrials and the medical profession, and the failure on the part of the latter to carry into practice in all its detail the same up-to-date surgical technic that is carried out in the average operating room. One would think that such a simple procedure as the aseptic and antiseptic treatment of simple wounds would be too primitive to permit of discussion, nevertheless, nine out of every ten doctors are very negligent in the treatment of these conditions.

It is not only in industrial plants, however, that we meet the problem of the "slightly wounded" in civilian life, for many of our hospitals have very inadequate provision for caring for minor injuries, and such cases are too often turned over to untrained and inexperienced operators.

The economic and the ethical importance of the proper care of punctured, incised, or lacerated wounds, practically all of which are contaminated and likely to become infected, has not been sufficiently emphasized. There is still too great a tendency to close such wounds primarily without proper cleansing,

rather than to leave them open and suture secondarily if the wound cannot be correctly disinfected at once.

This principle applies not only to the accident ward, but to the operating theatre as well, where the too frequent catastrophes following the so-called "slight" or "minor" operations testify to the neglect of some radical factor in proper treatment. In the great majority of hospitals "major" operations are most carefully governed by proper precautions. The operators are prepared for the possible emergency, an experienced, trained anæsthetist is employed, the principles of asepsis are rigidly observed. But the "minor" operations are too often undertaken by untrained and inexperienced men without proper guidance, regardless of the ever-present dangers of improper anæsthesia, of infection, of functional impairment; and the calamitous end results are out of all proportion to the small percentage of such results which could occur if every possible precaution were taken. Many practitioners are influenced by their patients who request surgical attention for some minor ailment, as they are not willing to suffer what seems to them a humiliation in refusing to perform the so-called minor operation.

Every surgeon recalls readily many occasions when he has been called upon to arrest hemorrhage after an inexpert circumcision or tonsillectomy; or to treat the serious and often fatal infection which has followed the removal of a corn, a uterine curettage, an attempt to remove an innocent looking tumor, or cutting into an aneurism, thinking it to be an abscess, etc. We are all familiar with cases in which functional impairment or loss has followed an attempt to remove a needle or other small foreign body without the aid of a properly taken X-ray picture and without sufficient aseptic precautions. We all know how the crippling results of transverse incisions of fingers or toes, of cutting tendons when abscesses are opened. We have seen too many cases of cellulitis following the removal of wens; and of the dire results of electrolysis in skin cases.

The catastrophes which may follow very serious imperative operations are often unavoidable and excusable; but the economic loss in time as well as the too frequent loss of life as a result of improper or delayed treatment, or of the inexpert performance of these minor operations under an untrained anæsthetist, have been too long endured.

What has been said regarding the treatment of the slightly wounded, may well apply to the average treatment of fractures. In spite of large experience in the treatment of fractures, we still see institutions which care for accident cases poorly equipped with proper appliances. We still note the transportation of fractured femurs and fractured arms without the application of proper splints. After witnessing the benefits secured in war casualties by the use of the Thomas splint, it would seem that every railroad and large industry, all ambulances and certainly all hospitals, should not only be plentifully supplied with this splint, but that all who are called upon to attend accident cases should be taught its proper application at least as far as transportation is concerned.

With the recent vast experience in the treatment of the slightly wounded in war as well as of the seriously wounded, with the outstanding picture of the vital effect upon the firing line, of inexpert or delayed attention to the slightly wounded; with our civilian experience of the baneful effect of the neglect of minor cases in civilian surgery, does it not become the duty of this surgical organization to call emphatic attention to the need of proper organization in our civilian hospitals and in our smaller communities to assure better attention to the lesser as well as to the greater injuries, to the minor as well as to the major operation? Suffering and disability to the individual and economic loss to the community may thus be minimized.

WHAT WOULD BE THE BENEFIT TO THE CIVILIAN SURGEON IN THE EXPERIENCE GAINED BY OUR MILITARY SURGEONS IN THE RECENT WORLD WAR? *

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THE civilian surgeon who has not been able to take an active part in the late war, and who has had little experience with military surgery, with possibly the exception of dressing a few wounds in the Spanish-American War, must gain much additional knowledge from the splendid papers that are now being presented on this subject. He must make his final deductions from this analysis of war surgery, as it bears upon the treatment of severe railway and industrial wounds. This also applies to abdominal, thoracic and head injuries, as well as the treatment of fractures and hemorrhage.

To the surgeon of large civil and hospital practice the papers in our medical journals, for the first two years, would make it appear that the actual progress has been comparatively small. Our aseptic technic broke down early in the war, and, apparently, the surgeon was compelled to fall back on first principles and the antiseptic method. In his reading the civil surgeon has in mind the great number wounded by the fearful effect of high explosive shells, of air bombing, of long distance artillery, of machine guns, mines and shrapnel, the laying down of the barrage, and compares them to his own surgical practice. Then there are also the accidents occurring aboard steamers, from a diversity of causes, the crashing of falling buildings, and fire walls, the explosion of powder magazines, likewise the more fearful crushing wounds that come from the falling of heavy bodies, all these tending to produce great shock.

It is here that additional experience is sought in the method of procedure, particularly in railway surgery, industrial accidents and the immediate treatment of hemorrhage.

In the transportation of wounded we have an illustration that can well be followed out in the treatment of railway cases, in the principles embraced in our trans-Continental hospital trains. The method of transporting wounded soldiers from the place of injury, and for long distances, by motor, water or railway train, presents a lesson that can be made applicable in civil practice. For some time the civil surgeon meeting with these conditions has recognized the serious additional depression of long transportation in this class of wounded, as well as cases of acute hemorrhage, and has said in his own mind, and in discussion, it is better that I hasten to the wounded man than that he be brought so far to me. This additional

* Read before the American Surgical Association, June 16, 1919.

exaction upon the patient's failing strength may be the last factor that terminates his case fatally.

The treatment of hemorrhage is one in which laboratory work, as well as the experimental efforts of many of our ablest civil surgeons, has resulted in great advances, but in the main will their conclusions be confirmed?

Have the excellent laboratories they had at the front made much clearer the subject of transfusion, either by the normal saline solution, and its modifications and the various preparations of blood, or the more direct, effectual and perfect method of blood infusion?

In the first and second years of the war the treatment of wounds, on the basis of the employment of sterile dressings, the sterilization of surgeon, patient, instruments, etc., left rather a cloudy, doubtful state of mind, in the civil surgeon, as to whether war surgery was accomplishing all that might be said of it, and in connection with our past knowledge of civil surgery. The loss of life from rapid infection following closed wounds, which became so serious, the loss of patients from tetanus—a condition that, in civil life, we felt was pretty well under control—the new kinds of wounds, from swift-moving heavy missiles at the same time shell wounds containing poisonous gases and trench fighting, which developed ground infection, all brought a shock to many an active civil surgeon, who had quite comforted himself with much better results than were early published regarding the treatment of wounds among the allied armies.

As a matter of fact in free suppuration and acute abscesses war surgery has not progressed much in advance of our other modern wars. We now know the cause of infection, but the treatment then was much the same as now.

Wounded are transported much more quickly than formerly, and are operated upon much more expeditiously, so that the risk of infection is less, but otherwise the treatment is much the same.

In the first years of the war it began to appear that the lower mortality rate was apparently due more to the treatment of diseased conditions of the men than to their surgical treatment.

Later, the prophylactic treatment of tetanus, the open treatment of serious wounds, the removal of tissue that would inevitably slough and cause infection, confirmed our experience in civil life. Here we felt that civil surgery was being paralleled, however, with this distinction, that war wounds, the serious nature to which I have referred, bring a more distinct line of injury to muscle, bone, nerve and circulatory system than the slow, crushing wounds of railway accidents, or the falling of heavy weights upon a limb in industrial injuries. In these cases many a civil surgeon was distressed to note the amount of serious infection and loss of life resulting in war surgery. We were not surprised to see a return to antiseptic surgery, the use of supposed germicides, and to note that the observing army surgeon, as reported from the active military hospitals in France, Belgium, and, to some degree, in England, were also experimenting in simply cleansing the wound, this line of aseptic treatment bringing better, and even excellent results.

Different methods bearing the name of eminent research workers, and laboratory surgeons, who have been able to carry their experiments into actual practice, are not yet so firmly grounded and present such uniform results as to convince the civil surgeon there is but one line of procedure, but one course to pursue in these cases.

Apparently the Carrel-Dakin method is of considerable benefit in the treatment of wounds of bones and joints, but it is very painful and the patients require large doses of morphine to make them comfortable. This and kindred methods are all good in their way, but much too complicated and costly to be used in ordinary civil hospital practice. Undoubtedly the Carrel-Dakin method is of much benefit when it can be carried out as planned by its author, but only a few civilian hospitals can furnish the nurses and attendants to do it properly.

Therefore, it seems to me the civilian surgeon may well continue the methods he has been accustomed to employ, and which have given him good results.

Reports from the large hospitals show that the wounded are still suffering from general sepsis a long time after the beginning of treatment, in spite of any of the methods employed.

The tests made, and the belief established that there must be a total absence of all pathogenic microorganisms from our field of operation when completed, and the wound ready for closure, have been given a severe trial.

It is possible, we must admit, that Nature is capable of doing a great deal in assisting the surgeon at this point, if she receives proper protection and encouragement by a not too severe antiseptic method.

Whatever we do we should constantly keep in mind our endeavor to obtain perfect wound healing, and surely this war has taught us that the pus-producing powers are always alert and ready to perform their unhappy intrusion in causing infection.

Any civil surgeon who has had an extensive practice and accustomed to being called to distant places in the country has been surprised to note the serious condition of the patient who had been injured less than twenty-four hours previously. Possibly the foot, leg or arm of the patient became entangled in the cutting bar of the mowing machine, or in some way in the reaper, or an open wound has been dragged over surface ground by some farm machine. In the former class of wounds, in going over the meadow, the surgeon was surprised to note how clean the grass or grain stubble appeared, or in the latter case the plowed ground would attract his attention regarding the possibility of infection from barnyard manure. In these cases he has also been surprised to observe how rapidly infection has taken place, and to find that already the lacerated wound of the arm, ankle or leg, with or without a fractured bone, had produced a swelling hardly to be realized in size; that when handling the parts there was to be noted a marked condition like that of emphysema of the chest, in a punctured wound of the lung. Recent work in the laboratory has told him that this is an infection

caused by the bacillus aerogenes capsulatum, gas infection. If yet within the treatment of surgery it would perhaps mean the loss of the limb or immense sloughing or, at least, requiring free incision and drainage, while the serum treatment has seemed to do some good.

In the treatment of gas gangrene, it is hoped such a thorough trial will be made of Doctor Flexner's antitoxin as to bring us further and reliable data.

We were not surprised to hear of these war cases, and the term hospital gangrene had only a meaning of location. We have watched treatment with keen interest, and believe much credit is due some of our army surgeons for their exceedingly forceful, brave, operative intervention.

I believe I echo the opinion of many civil surgeons by emphasizing the belief that in the treatment of these cases something has been gained from the reports we have received to date through our medical journals, specially regarding the manner of doing the required amputations.

Then the civil surgeon reviews in his mind the final analysis in the use of anæsthetics; what additional knowledge will we acquire from the experience of our able war surgeons on this subject? We fancy, if we refer to the statistics of to-day, we are somewhat inclined to the belief that ether and chloroform have sustained their past reputation as anæsthetics, but, on the other hand, that the employment of nitrous oxide, together with oxygen, has found a substantial lodgment, and is to be respected in the treatment of shock cases, here bringing better results than have heretofore been deemed possible; that local anæsthesia has not advanced greatly in its application to military wounds is not disappointing. (Undoubtedly much good is to follow the careful study and presentation of papers by our returning surgeons, as well as the discussions that must inevitably result in such meetings as we are now holding in Atlantic City.)

Undoubtedly in the treatment of fractures important advances have been made. The use of the Thomas splint and methods employed by Doctor Blake and other surgeons have been of great benefit and have marked quite an advance in that direction. Also we have grown away from bone-plating and the use of artificial methods to encourage the healing of fractures.

The standardization of splints is likely to make a favorable impression, and be of great value. This is also applicable to the dressings accompanying the employment of the simplified and most practical splint, doing away with the frequent examination of wound dressings, and making transportation much more comfortable for the patient; however, in the actual use great care must be exercised, and joints watched, especially knee- and hip-joints regarding any malposition that may be produced.

Possibly, in connection with this work, we are to have more complete and exact results from X-ray investigation. More exact experts undoubtedly will develop radiographs that can be interpreted so clearly and convincingly to the civilian surgeon as to be of great help to the latter.

The report on the work of the X-ray laboratory at the front is likely

to present an amount of information that will be of great value to the surgeon in civil life.

In wounds of the abdomen, regarding the first suggestion of not operating until reaction had taken place, our surgeons have gone back to the original technic of operating as soon as possible after the receipt of the wound and with as little transportation of the patient as necessary. In this method of operating serious hemorrhage is controlled and the closing of the opening in the intestinal tract lessens negative traumatic peritonitis.

In the treatment of wounds of the chest we have learned much, and in my opinion that is the greatest advance which surgery has made in this war. Apparently it has been demonstrated that the thoracic cavity can easily be opened with almost as much impunity as that of the abdomen, joints or the brain. And it is along the line of thoracic surgery that our next great surgical advance has already been or will be made.

Of the major operations that have been performed in this war, it is believed there will be shown a much less percentage of amputations and that the recoveries in operations done within the abdomen will be greater than in any previous war. This will also embrace operations within the thorax.

In the operations about the head statistics thus far accumulating develop the fact that the steel helmet has certainly been a source of great protection, there being fewer scalp wounds and evidence of injury to the skull. Can we gain anything from this in protecting our industrial workers?

A factor of great importance presents in the reconstructive work that is being executed so thoroughly by and under the direction of the Surgeon General. The liberal appropriations made by the government enable the fitting out of assigned hospitals for doing this work on a more extensive scale than has yet been established by the generosity of private individuals or public hospitals.

The wounded soldier, as well as those yet suffering from the effects of army exposure and disease, is not permitted to his home until everything possible has been done for him.

It must be recognized that the United States Government has given to the Surgeon General's office a very generous amount of funds so that everything pertaining to up-to-date surgery and hygienic apparatus has been furnished.

The profession and public at large are hoping for great benefits to accrue to these wounded patriots, and in the final analysis the civilian surgeon must gather a vast amount of practical and valuable information.

Above all would the civil surgeon recognize the immense advance that has been made in the system of nursing, in the preparation of dressings, and through the Red Cross work by the women of America, who have worked so faithfully, so intelligently, so persistently in their efforts to help the American soldier?

RÖNTGENOGRAPHY OF THE BRAIN AFTER THE INJECTION OF AIR INTO THE SPINAL CANAL

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As was shown in a recent publication,¹ one or more of the cerebral ventricles can be sharply outlined in a röntgenogram if the ventricular fluid be withdrawn and replaced by an equal quantity of air. In the course of this work it was soon noted that in many cases some of the air had passed out of the ventricular system and could be seen in filaments on the surface of the brain, that is, in the sulci. In order to reach the sulci from the point of injection in a lateral ventricle, the air must have followed the normal pathways by which cerebrospinal fluid circulates. It must have passed through the foramen of Monro into the third ventricles, thence into the fourth ventricles, through the aqueduct of Sylvius, and then, having left the ventricular system, it must have entered the cisterna magna by way of the foramen of Magendie and the paired foramina of Luschka. Finally, from the cisterna magna it must have passed along the various cisternæ under the base of the brain and then by numerous branches have reached the termination of the subarachnoid space—the sulci. Not infrequently, the entire subarachnoid space was graphically defined by the air shadows.

These observations at once gave promise of new possibilities in intracranial diagnostic study. Many lesions of the brain affect part of the subarachnoid space directly or indirectly. In hydrocephalus of the communicating type, adhesions at the base of the brain obliterate the cisternæ and the cerebrospinal fluid cannot reach the sulci over the cerebral hemispheres; a local area of subarachnoid space may be obliterated by a tumor situated on or near the surface of the brain; a defect in the brain due to atrophy must necessarily be filled with cerebrospinal fluid, which may maintain communication with the subarachnoid space. These, and no doubt many other conditions, should be demonstrable by the absence or by the presence of air over the cerebral hemispheres.

After the injection of air into a cerebral ventricle a certain amount will soon appear on the external surface of the brain if the head is carefully manipulated so that the air is guided to the small aqueduct of Sylvius and the fourth ventricle. But the time of escape of air from the ventricles and of its appearance in the cerebral sulci are variable. The more completely the ventricles are filled with air the greater the probability that it will appear externally; and the more dilated the iter and the foramina of Luschka and

¹Dandy, W. E.: *Ventriculography Following the Injection of Air Into the Cerebral Ventricles*. ANN. SURG., July, 1918. *Fluoroscopy of the Cerebral Ventricles*. The Johns Hopkins Hosp. Bull., February, 1919.

Magendie (as in hydrocephalus) the more readily will air appear externally. Nevertheless, it was evident that at best the amount of air that will reach the cerebral sulci must vary greatly, according to the conditions existing in each individual case.

The problem therefore before us was: How can we in every case be sure of obtaining a complete injection of the subarachnoid space? The solution lies in the direct injection of air into the spinal canal. By this method the influence of the ventricular system is entirely eliminated; the air passes directly into the cisterna magna and thence into the ultimate ramifications of the subarachnoid space.

The technic is essentially similar to that described elsewhere for intraventricular injections. A small quantity of spinal fluid is withdrawn and an equal amount of air injected into the spinal canal. This process of substitution is repeated until the fluid ceases to appear on aspiration. There is no need to sterilize the air, because it is always free from pathogenic organisms.

Undoubtedly this procedure is not devoid of danger. Medullary distress, even fatal results, might well follow from increased intracranial pressure if the amount of air injected were even slightly in excess of the fluid withdrawn. The danger would certainly appear to be much greater in intraspinal than in intraventricular injections, because in the latter direct pressure on the medulla in large measure is inhibited by the tentorium cerebri. In my own cases no bad effects have followed and the results have led me to believe that with proper care and judgment the procedure is entirely harmless. I have always left the open needle in the spinal canal for two or three minutes after the injection has been finished, thus rendering the intraspinal pressure directly under control. If the needle is left open, the intraspinal becomes equal to the atmospheric pressure, which is less than the normal intraspinal pressure. This reduced pressure is an additional safeguard against any possible development of a "reactive" intracranial pressure.

The position of the body is all-important in intraspinal injections—in fact, in all air injections, because the air rises as the fluid gravitates. The head must be at least twenty degrees higher than the needle. With each injection the air will then rush to the brain and a new supply of fluid will fall to the point of the needle. No doubt the sitting posture would be more satisfactory, because it would allow a more complete and uniform injection of the subarachnoid spaces over both cerebral hemispheres. In the recumbent position, which I have used exclusively, mainly for the comfort of the patient, it is possible that the injection may be more complete over the surface of the higher hemisphere than over the lower hemisphere, and that on turning the patient from one side to the other (in order to take both right and left lateral views of the head) important changes in the distribution of the air may be induced by the effects of gravity. In the sitting posture, rotation of the head would not alter the position of the air in the spaces, because gravity would not be brought into play, and a more accurate photograph

of the "air mantel" on each hemisphere would be obtained. If, however, the intracranial subarachnoid space is thoroughly injected, there should be but little change due to gravity and the recumbent posture should prove practically as effective as the sitting posture. Additional experience will probably indicate the position of choice.

I have injected air intraspinaly into eight patients—four children and four adults—from Professor Halsted's service, without any bad effect. The amount of air has varied from 20 to 120 c.c. In one patient a mild headache followed but disappeared in three hours; vomiting but no headache occurred in another case; in the others no complaints were made. In reality, the effects should be much the same as those following the usual lumbar puncture.

One difficulty in the injection procedure should be mentioned. The aspiration must be gentle because the needle may plug at times, presumably with fibres of the cauda equina. If the suction is very gentle this may be obviated. In no case was there pain from injury to the nerves.

It must always be remembered that spinal punctures are very dangerous in all patients with intracranial tumors. A spinal puncture should never be made (if a tumor is present) unless the intracranial pressure has been previously relieved by a ventricular puncture or by some other procedure.

What becomes of the air? Air disappears from the subarachnoid space quite rapidly. It is absorbed as from other tissue spaces and undoubtedly passes directly into the blood. Usually no air is demonstrable in the röntgenogram twenty-four hours after the injection. Absorption from the subarachnoid space is many times faster than from the ventricles.

Practically all cerebrospinal fluid is absorbed from the subarachnoid space; very little from the ventricles, and the absorption of ventricular fluid occurs only after it has passed into the subarachnoid space.² When air is injected into a lateral ventricle, its rate of absorption seems to depend upon the freedom of access to the subarachnoid space. If the ventricles are normal the air will disappear in the course of a few days. If an internal hydrocephalus is present, the absorption time is greatly increased because an obstruction prevents the air from reaching the subarachnoid space. In cases of ventricular dilatation it may require two to three weeks for the air to disappear. The rate of absorption of air from the ventricles and the subarachnoid space appears to be relatively the same as that for the absorption of fluids from these cavities, although the absolute time required is greater for the absorption of air.

Röntgenography of the Normal Subarachnoid Space.—If the spinal and intracranial subarachnoid spaces are normal, the air which has been injected intraspinaly will fill all the intracranial spaces (Figs. 1-3). The cisterna magna shows as an air-filled space of varying size, anterior to the squamous part of the occipital bone. The cisterna chiasmatica, which is the anterior

² Dandy, W. E., and Blackfan, K. D.: Internal Hydrocephalus. *Am. J. Dis. Child.*, 1914, viii, 406. Second paper: *Am. J. Dis. Child.*, 1917, xiv, 424. Also: *J. Am. M. Ass.*, 1913, lxi, 2216.

terminus of the cisternæ, usually shows quite distinctly, and from it several branches may be seen passing upward into the cerebral sulci. The intensity of the shadow of the cisternæ under the medulla, pons, and midbrain is greatly modified by the dense bone at the base of the skull, notably the petrous part of both temporal bones. The continuity of the shadow of all the cisternæ can, however, nearly always be traced if the X-ray is good and the injection has been complete. The sulci appear as a network of lines over all the surfaces of the cerebral hemispheres. In general appearance the injected sulci suggest very closely the shadows of the vessels in the diploe, although the arrangement is different. In the earlier ventriculograms, in which only a few sulci contained air, the shadows were erroneously looked upon as markings of the diploëtic veins. Sulci have not been observed around the cerebellum, but frequently an envelope of air can be seen completely surrounding it. This envelope of cerebellar air is continuous with the cisterna magna. In one plate in which the upper part of the spinal canal was included, the spinal subarachnoid space was full of air, and in this column of air the shadow of the spinal cord was very distinct (Fig. 5).

The cerebellum frequently appears as an island (Fig. 3). Since the tentorium cerebelli is in apposition with part of the pericerebellar subarachnoid space, the shadow of this space marks the under surface of the tentorium. In cases in which the lateral ventricles are enormously dilated, a ventriculogram will delimit the upper margin of the tentorium. By combining the upper and lower shadows in such a case, the outlines of the tentorium are quite sharply seen. Mention of this is made merely to show how sharply the X-rays will differentiate tissues in a medium of air.

Localization of Intracranial Lesions by Intraspinal Injections of Air.^a—The cisternæ may be regarded as the vital part of the subarachnoid space. Inasmuch as they form the trunk of the subarachnoid tree, all cerebrospinal fluid must traverse them in order to reach the cerebral sulci. The sulci are important because in them practically all cerebrospinal fluid is absorbed. Any obstruction in the cisternæ, therefore, leads to hydrocephalus because of a diminished absorption of cerebrospinal fluid. Hence it becomes of the utmost importance to determine whether the cisternæ are patent or whether they have been obliterated. Intraspinal air will always reach the sulci if the cisternæ are patent; and conversely, if the air does not reach the sulci, the cisternæ must be obstructed at some point. Furthermore, with a good X-ray one can see just where the obstruction is situated.

In this series of eight cases, the location of the lesion has been accurately determined in three. In the remaining five, the subarachnoid space was normal. In the three patients in whom the lesion was located by means of intraspinal air, other methods had entirely failed. The findings in these cases will be briefly stated.

^aThe röntgenographic detail in these plates we owe to the skill of Miss Mary Stuart Smith, in the X-ray service of Doctor Baetjer.



FIG. 1.—Photograph of a roentgenogram of the head after injection of air into a lateral ventricle. The air has passed out of the ventricular system and filled the cerebral sulci, which appears as a network of lines. The cisterna interpeduncularis and the major branches passing to the cerebral sulci are fairly distinct just above the sella turcica. The lateral ventricle is normal.

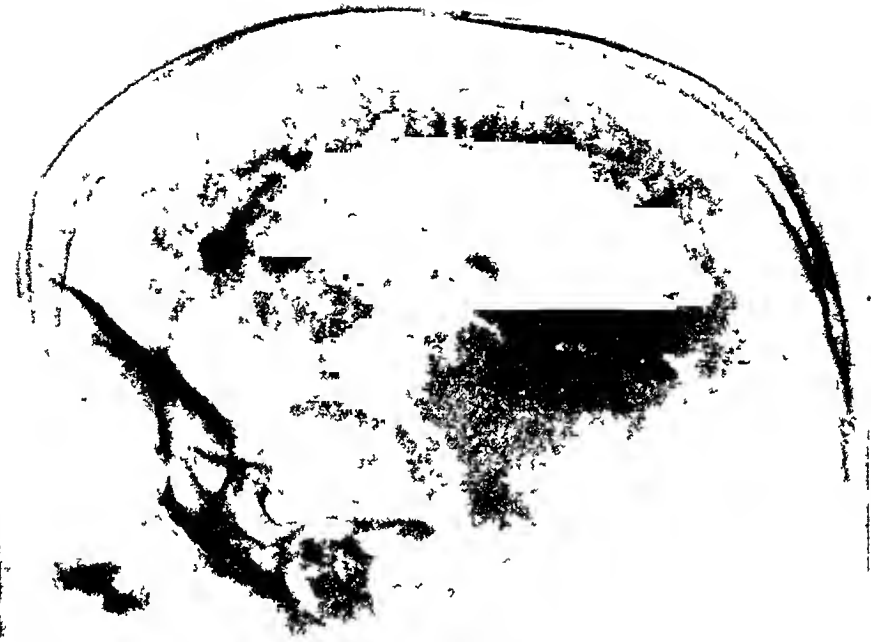


FIG. 2.—Photograph of a roentgenogram of the head after an intraspinous injection of air. The sulci and cisterna are more distinct than after the intraventricular injection as shown in Fig 1.

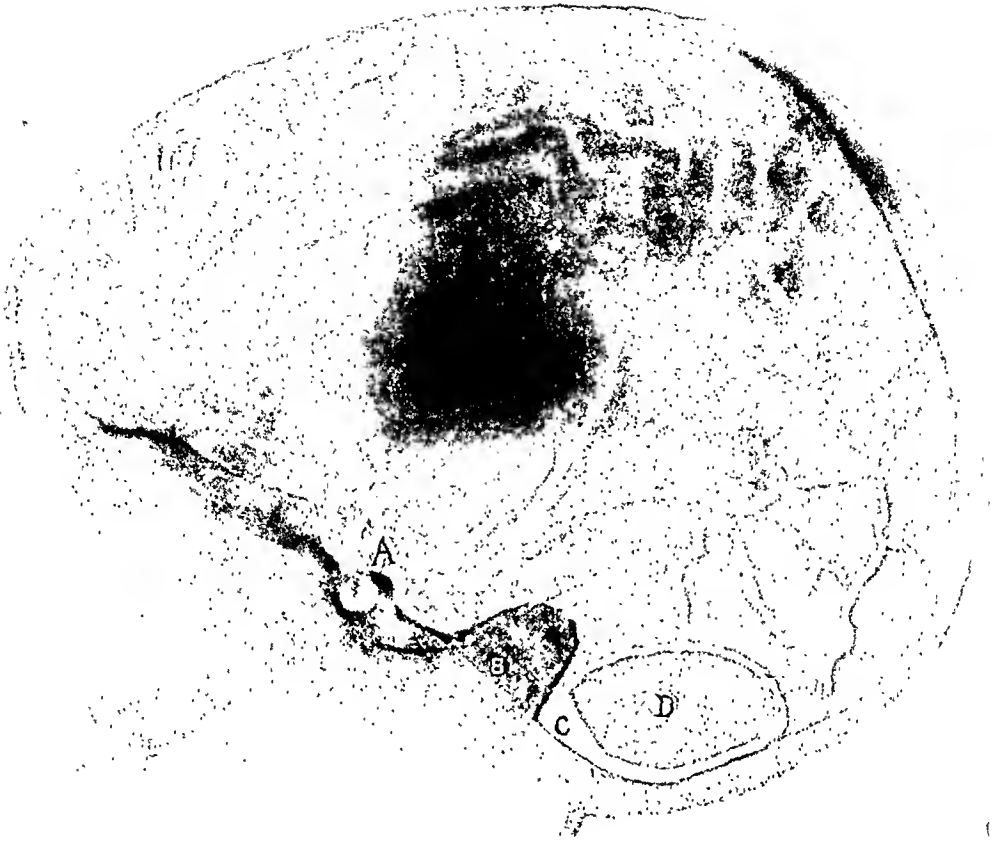


FIG. 3.—A retouched photograph of a roentgenogram of the head after an intraspinal injection of air. The subarachnoid space is probably normal. The lines of the component parts of the subarachnoid space have been intensified because of the loss of detail through photographic reproduction. A, cisterna interpeduncularis; from it many large branches can be seen establishing direct communication with the cerebral sulci. B, cisterna shadow subdued by the dense temporal bones. This part of the cisterna can be seen in many X-rays. C, cisterna magna; from it the cerebellar subarachnoid space completely encircles the cerebellum (D). The large horizontal sulcus shown directly connecting with the cisterna, in all probability, is on the mesial aspect of the brain and passes around the corpus callosum. It is impossible to tell which of the other sulci are median and which are external.



FIG 4 —Retouched photograph of a roentgenogram of the head after an intraspinal injection of air. The patient had internal hydrocephalus. It will be noticed that none of the sulci are injected as in Figs 1, 2, and 3. At the arrow, an obstruction due to adhesion has blocked the cisterna. A, cisterna pontis and medullaris. B, cerebellar subarachnoid space, also only partly open. C, cisterna magna, considerably enlarged. D, lateral ventricle which partially filled with air after the intraspinal injection.



FIG. 5.—Retouched photograph of a roentgenogram of the head, after an intraspinal injection of air. The patient was suffering from the effects of an intracranial tumor which was localized only by the aid of the air injection and after a cerebellar exploration had revealed no growth. The operative defect in the occipital bone can be seen. In this region an enormous collection (C) of cerebrospinal fluid has accumulated. This corresponds to a greatly enlarged cisterna magna. Even the upper part of the spinal cord is visible because the spinal canal is filled with air. B, cisterna medullaris and pontis. The arrow points to the block in the cisterna. Here, a midbrain tumor was found and partially removed through a tranocerebellar incision. It had closed both the aqueduct of Sylvius and the cisterna. The large collection of fluid (C) is due to the occlusion of the cisterna. It will be seen that none of the cerebral sulci contain air.



FIG 6 —Photograph of roentgenogram of head after injection of air into ventricle (not retouched). This patient had an early hydrocephalus following acute cerebrospinal meningitis. Only a small area of the cerebral sulci contain air (cf. brackets between X and X on surface). The obstruction which caused the hydrocephalus was not in the cisternæ but in the main branches which radiate to the sulci. The arrow points to the cisternæ which appear as a series of "blotches", part of this appearance is probably due to the dilated trunks (obstructed above) which pass from the cisternæ to the cerebral sulci. The partial filling of the cerebral sulci (X to X) explains the slow development of the hydrocephalus. C, cisterna magna.

In a case of hydrocephalus, 110 cc. of air were injected intraspinaly. It filled the cisterna magna, extended along the cisterna medullaris, and was stopped at the point of obstruction in the cisterna pontis (Fig. 4). This obstruction, due to adhesions from meningitis, had prevented the air reaching the sulci and thereby caused hydrocephalus. Necropsies have shown that communicating hydrocephalus is usually caused by adhesions in the cisternæ.⁴ I have since produced this disease in animals by occluding the cisterna with a perimesencephalic band of gauze.⁵

The injection of air gave still further information. Although it could not reach the cerebral subarachnoid space, which is normally the path of least resistance, it passed through the basal foramina of Luschka and Magendie, the fourth ventricle, the aqueduct of Sylvius, the third ventricle, the foramen of Monro, and partially filled a lateral ventricle (Fig. 4). The fact that the air passed into the ventricle showed that the hydrocephalus was of the communicating type. It should be noted that air has not been observed to enter the ventricle except in hydrocephalus. Normally, the cerebellum is in such close apposition to the floor of the fourth ventricle that, despite the absence of valves, the retrograde flow of air into the fourth ventricle is prevented. It is conceivable that the precise localization of the obstruction by the air method may render operative relief for the obstruction possible.⁶

Our second case presents an even more interesting pathology. The patient was a child three years of age. She had passed through an attack of acute cerebrospinal meningitis, but instead of complete recovery, lethargy and vomiting had ensued. Internal hydrocephalus was suspected by Doctor Blackfan, and confirmed by ventriculogram. A month later a second ventriculogram showed a measurable increase in the size of the lateral ventricle, but the rate of growth was markedly less than in the typical form of this disease. The air passed freely along the cisternæ and into the sulci over a very restricted area of the cerebral cortex (Fig. 6), not more than one-fourth of all the sulci showing the injection. Nor could it be determined whether the injected area was bilateral or unilateral. Exactly the same röntgenographic findings were present in the two X-rays taken a month apart; in fact, the same convolutions could be traced in both. The sulci could be followed into the cisterna chiasmatica.

These data supply a new conception of the pathology of hydrocephalus. The inflammatory process has sealed off all the main branches which radiate from the cisternæ, with the exception of one or possibly more which supply the anterior fourth of the cerebral cortex on one or possibly both sides. Absorption of cerebrospinal fluid from this restricted area has been sufficient to retard to a great extent, though not to prevent, the development of hydrocephalus. Should more branches from the cisternæ subsequently open, it is quite probable that, owing to the increased absorption which would follow, the accumulation of fluid will be entirely arrested. Such a development could easily explain many spontaneous cures in hydrocephalus. It is very doubtful if these pathological changes in the brain would be detected at necropsy.

A third case was in a boy of nineteen, who was suffering from intracranial pressure. An internal hydrocephalus was discovered. But what had caused the hydrocephalus? From his symptoms a tentative diagnosis of a cerebellar tumor was made, and since the signs and symptoms pointed to both sides equally, a vermis tumor seemed most likely. After a thorough cerebellar exploration I was unable to find any trace of the

⁴Dandy, W. E., and Blackfan, K. D.: Internal Hydrocephalus (second paper). *Am. J. Dis. Child.*, 1917, xiv, 424.

⁵Dandy, W. E.: Experimental Hydrocephalus. To appear in *ANNALS OF SURGERY*.

⁶In the December number of the *ANNALS OF SURGERY*, 1918, I presented a form of treatment for communicating hydrocephalus. If it should be possible, in a certain number of cases, to restore the channel of the cisternæ, this treatment would be superior to a bilateral choroid plexectomy.

tumor. The foramen of Magendie was normal. Three weeks after this operation, the phenolsulphonephthalein test showed that a complete obstruction was present at some point between the third ventricle and the foramen of Magendie. Air (120 c.c.), injected intraspinaly, was stopped in the anterior end of the cisterna pontis; none reached the cerebral sulci (Fig. 5). These findings could admit of only one interpretation—the pressure of a tumor in the region of the aqueduct of Sylvius, which had occluded it and the cisterna pontis. At operation a tumor as large as a hickory nut was found in the midbrain, and partially removed after bisection of the vermis of the cerebellum. The iter had been completely obliterated by the tumor.

Another interesting radiographic finding in the case was the enormous amount of fluid which had collected at the base of the brain after the first operation. We have frequently noticed after cerebellar operations in which a tumor was not found that such an accumulation of fluid followed, but the explanation had never been clear. The X-ray picture seems to indicate that the closure of the cisternæ causes the fluid to accumulate, or, in other words, bring about a localized hydrocephalus; the fluid forms in the fourth ventricle (the iter being closed). Another point of interest in this röntgenogram is the sharp outline of the spinal cord (Fig. 5).

A fourth case was that of a boy of eighteen. Hydrocephalus of a year's standing had followed an acute illness which had been diagnosed as measles. At operation the hydrocephalus was found to be due to closure of the foramina of Luschka and Magendie by dense adhesions. I made a new foramen of Magendie and wanted to be sure that it was functioning before allowing the patient to go home. Six weeks after the operation, air injected into the ventricles passed through the new foramen of Magendie and filled the cisterna magna and many of the cerebral sulci. We now could feel certain not only that the foramen of Magendie was patent, but also that all the subarachnoid space was receiving cerebrospinal fluid for absorption. The boy has since resumed his studies in college.

It also seems probable that we shall be able to localize spinal cord tumors by means of intraspinal injections of air. In one of our cases (Fig. 5) the spinal cord and the surrounding air-filled space are sharply outlined. Should the spinal canal be obliterated, either by a tumor or possibly by an inflammatory process, it is conceivable that the air shadow will extend up to the level of the lesion. Its intensity will naturally be greatly reduced by the great density of the spine, and particularly of the bodies of the vertebrae. A lateral view of the spine, by eliminating the maximum amount of bone, will probably give the best results. If the spinal canal is not obliterated by the tumor, the injected air will pass freely into the intracranial subarachnoid space, none being left in the spinal canal. This happened in one of our cases in which a spinal cord tumor was suspected. The passage of air into the brain was difficult to explain at the time of the injection, as the symptoms had been present for four years and a tumor of such duration would certainly have blocked the spinal canal. At operation a chronic transverse myelitis was found. Instead of an enlargement of the spinal cord, there was a constriction, which readily explained the failure of air to stop at the suspected zone.

As yet we have not had an opportunity of studying the radiographic findings in tumors of the cerebral hemispheres. It is conceivable that local effects may be noted in the sulci, or possibly even the direct or indirect effects of pressure on the cisternæ may be discovered.

The practical value of intraspinal injections has been thoroughly established by the results in the few cases here reported. As a matter of fact, we shall often be able to localize a tumor from either a ventriculogram or from an X-ray of the subarachnoid space alone, an analysis of the signs and symptoms of the individual case enabling us to determine which should be tried first. From the data obtainable from the combination of intraventricular and intraspinal injections it is difficult to see how intracranial tumors can escape localization.

CONCLUSIONS

1. By substituting air for cerebrospinal fluid through a lumbar puncture, all parts of the subarachnoid space can be clearly seen in a röntgenogram.
2. Not infrequently, an air shadow will completely surround the cerebellum, showing clearly its size and shape.
3. The spinal cord can be seen surrounded by a column of air.
4. The cisternæ appear as large collections of air at the base of the brain; the cerebral sulci as a network of tortuous filaments of air.
5. After an intraspinal injection, provided that the subarachnoid space is intact, the air will always fill the cerebral sulci.
6. But if the cisternæ are blocked at any point by a tumor or adhesions, the air will not be able to reach the cerebral sulci.
7. The exact position of the obstruction in the cisternæ can often be seen in the radiogram. In one of our cases of communicating hydrocephalus, the obstruction was in the cisterna pontis. In a second case of communicating hydrocephalus the cisternæ were patent but all except one or two of the main branches were occluded. In a third case a tumor was located in the midbrain solely by means of the radiogram.
8. In a case of hydrocephalus, air passed from the spinal canal into the lateral ventricle, demonstrating the patency (and dilatation) of the foramina of Magendie and Luschka, the aqueduct of Sylvius, and the foramen of Monro. The hydrocephalus was, therefore, of the communicating type.
9. A case of hydrocephalus was cured by constructing a new foramen of Magendie. Six weeks later, air injected into the ventricles passed through the new foramen, showing that it was still functioning. The air also filled the cerebral sulci, an indication that the entire arachnoid space was patent.

EXPLANATION OF FIGURES

Much detail is lost in photographing and reproducing the figures. Figs. 1, 2 and 6 have not been retouched. Figs. 3, 4 and 5 have been retouched (even to the extent of being almost diagrammatic) in order to show clearly the essential details which otherwise would have been lost to the reader.

FRACTURE OF THE SKULL WITH SPECIAL REFERENCE TO ITS NEUROLOGICAL MANIFESTATIONS

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THE abundant opportunity afforded by the military emergency of studying injuries of the skull and brain has been put to such good use in affording us a newer conception of the possible neurological complications of fracture of the skull, that it has seemed advisable to review again a series of these latter injuries occurring in civil life, especially from the point of view of the neurological surgeon. The feasibility of making this comparison has been much amplified by the circumstance that during the past five years neurological cases—including skull fractures—have been segregated to a single service at Mount Sinai Hospital; more intensive study of individual cases has therefore been possible.

GENERAL INFORMATION

Incidence.—There have been 75 cases of fracture of the skull in the hospital in the last five years. This represents the incidence of these injuries in ordinary civil life in a district devoid of factories. The accidents practically invariably occurred in the vicinity of the hospital, to which the patients were brought, and the opportunity has, therefore, been presented for studying the clinical pictures from their very beginning.

The age and sex distribution is shown in the following tables:

Ages.—From 1 to 5 years, 20 cases; 5 to 10 years, 30 cases; 10 to 20 years, 4 cases; 20 to 30 years, 1 case; 30 to 40 years, 4 cases; 40 to 50 years, 3 cases; 60 to 70 years, 5 cases; unknown years, 5 cases. Total, 72 cases.

Sex.—Males, 54 cases (adults, 12 cases; children, 42 cases); females, 18 cases (adults, 3 cases; children 15 cases).

The great majority of the fractures occurred in the first decade of life, the larger proportion in the second half of this period. There were three times as many fractures in the male as in the female sex. This preponderance among children is not extraordinary, since most of our cases resulted from street accidents, or from falls into cellars or from the upper stories of buildings; both of these causes are apt to operate much more commonly in children.

Causes and Mechanism.—The actual mechanism of the fractures as determined from the table of causes has almost always been a direct blow. In many the fractured area was limited and lay directly under the point of application of the provocative cause; in the others the fissures

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extended over a wide area of the vault; or the injury was limited to the base, either unilaterally or symmetrically on both sides. Many of these were bursting fractures. It has never been possible to exclude the likelihood that some, at least, of the cases in the latter group were due to the direct impact of a line of force delivered through the lower jaw and its condyles, inasmuch as the patients were frequently unable to indicate accurately the part of the head struck, especially when the mechanism was part of a street car or automobile accident. The presence or absence of abrasions on the jaw or face is no absolute proof, either one way or the other, because the fracturing force may have been transmitted through the intermediation of some other part of the body (sudden and sharp forcible flexion of the head, the point of the chin striking the thorax).

CAUSES

Falls (into cellar; from upper story; striking curb) .	34 cases
Automobile accidents	16 cases
Blows	7 cases
Car accidents	5 cases
Unknown	10 cases

Location and Topography of Fractures.—The locations of the fractures have been as follows:

Frontal	9 cases
Parietal	15 cases
Fronto-parietal	6 cases
Fronto-parieto-occipital	1 case
Parieto-occipital	6 cases
Petrous and sphenoid	2 cases
Temporo-parietal into middle fossa.....	1 case
Temporo-parieto-occipital	4 cases
Parieto-mastoid	2 cases
Middle fossa	1 case
Posterior fossa into ear	1 case
Basilar	1 case
Not determined or noted in history	23 cases

Most of the fractures have been simple fissures; these have been of a variable length, frequently involving more than one of the bones of the skull. The direction of the fissures has usually tended to the vertical or oblique, those behind the coronal suture running downwards, or downwards and forwards, in the general direction of the middle cranial fossa, those in front of the coronal suture running downwards towards the anterior cranial fossa. In those who, for one or another reason, were subjected to operation, it was frequently found that the extent of the fracture exceeded the pre-operative expectations. In a small number the fissures assumed a transverse direction. In one case there were two parallel fissures about four inches long with a finger's breadth interval between, running through the frontal, parietal and temporal bones and about a finger's breadth above the auricle. In one of the cases the frac-

tured edges were separated by an appreciable interval and the dura projected between; in all the others this interval was lacking.

A knowledge of the topography of the fissures in the skull is of importance, inasmuch as it is the present consensus of opinion that the direction of the fissures is parallel to the lines along which the fracturing force is delivered; on occasion this may have a medico-legal bearing.

Comminution with depression was present in only eight of the cases. The depressions assumed especial significance in the neighborhood of the venous sinuses: complications then very commonly occurred which made operation imperative, the most frequent of these being hemorrhage and compression. In one other case there was much comminution in the vicinity of the parieto-occipital angle without depression; there were no symptoms or objective findings indicating the necessity for operation and the patient made an uneventful spontaneous recovery.

Coincident Brain Injury.—In the cases in which operation seemed necessary injury of the subjacent brain was very commonly found with and without laceration of the overlying dura. The extent of the damage done to the brain was frequently much larger than that to the skull; and the nature of the cortical injury gave one the impression that the major portion did not extend very deeply into the brain substance. From various sources the impression has been conveyed that in the post-mortem room injuries of the brain are frequently found on the side of the head opposite to that which had received the trauma; the most common combination to find is a fracture of the skull in the general neighborhood of one parietal eminence with or without an underlying brain injury, and a contusion or laceration of the cortex with more or less extensive hemorrhage in the general region of the tip of the opposite temporo-sphenoidal lobe. For injuries of this kind a *contre-coup* mechanism has been assumed. One such case has been met with in this series, of which the clinical notes follow:

Hospital No. 186858. An eight-year-old boy was brought to the hospital with an injury in the left parietal region. He rapidly became unconscious. Later he passed into a semiconscious state, vomited, was very restless, and, in his lucid moments, complained of frontal headache. There were irregular and unequal spastic convulsions in the left hand and right foot, the toes of the latter assuming a position of plantar flexion. There was a large hæmatoma in the left parietal region but no other evidence of the location of the injury could be discovered. The pupils of the eyes were unequal; in the right eye there was no reaction to light, and the fundus showed some hemorrhage and a beginning papilloedema; in the left eye the pupil reacted to light and the fundus showed a large hemorrhage. The extremities were alternately flaccid and spastic. The upper and lower reflexes were present, equal and not exaggerated; a bilateral ankle clonus and Babinski could be elicited.

Operation was done four hours after the accident. The hæmatoma was opened and in its bottom a long fissure was seen in the parietal bone running backwards to the occiput; a button of bone was lifted out and, the dura appearing normal, the button was replaced and the outer wound was sutured. Then a right subtemporal decompression was done; here there was a large hemorrhage underneath an intact dura with a much lacerated and contused brain.

The operation was followed by an uneventful convalescence and on discharge from the hospital the neurological status of the patient was normal.

X-ray Studies.—Röntgenographic studies were invariably made in all of the cases except in those who were admitted in a moribund condition. In a small proportion of the patients the lines of fracture were not visible on the plates; this is probably so because in a fissured fracture the opposing surfaces can be so closely adapted to one another as to give no opportunity for a difference in texture sufficient to throw a distinguishing shadow on the X-ray plate. On one occasion this observation has been corroborated by the opportunity afforded by post-mortem examination.

When the fracture involved the floor of the skull in the region of the accessory sinuses, the lines of fracture were difficult, if not impossible, to make out because of the numerous planes of bony tissue which, crossing and overlying one another in an equally numerous number of ways, oftentimes created on the plate an uninterpretable picture.

Symptomatology—General.—The general symptoms of brain irritation were not always present and in those of our patients who were "neurologically negative" they were practically absent. In the others the range of variation was very wide. Vomiting was very frequent; most often it occurred within a few minutes of the injury; rarely was it repeated to any great extent, or did it last longer than the first twenty-four hours. Headache was nearly always present; in a few it was mild and evanescent; in much the larger number, however, it lasted for many days and in some for a number of weeks before it disappeared. It was generally of a diffuse variety, though in some it seemed to be at its maximum in the general region of the injury. Dizziness was a symptom that was rather rarely seen.

A loss of consciousness was not always described; this happened in the cases with scalp wounds in whom fractures were only determined later by the X-ray. Even among these, however, there were cases with a momentary loss of consciousness. In all the others there was either a transient or more persisting loss of consciousness; and corresponding with the presence and degree of concussion, of compression, or of both of these coexisting or succeeding one another, consciousness was recovered very quickly, or more slowly, or only temporarily to pass into a deeper stupor or coma. In those beginning to regain their normal func-

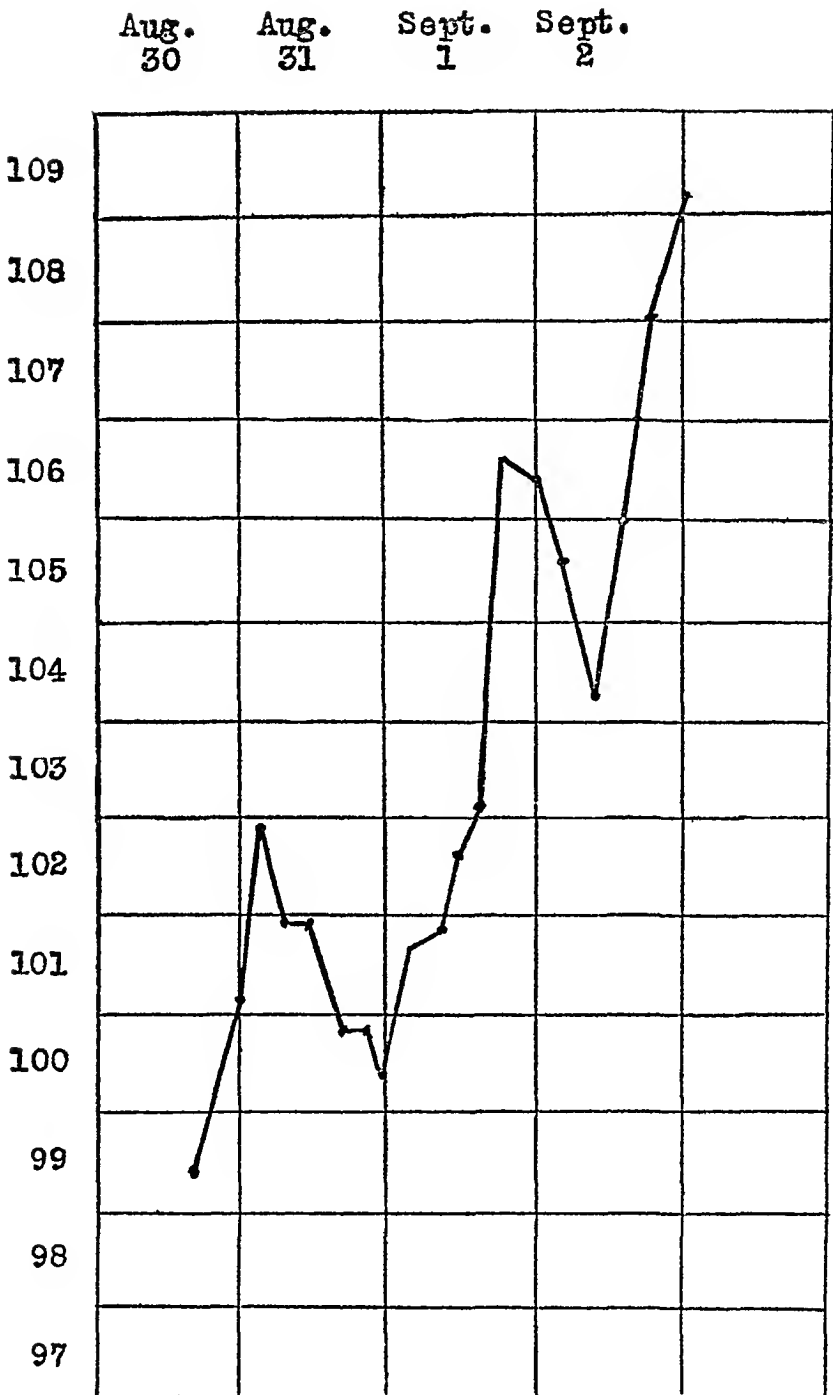


FIG. 1.—(Hospital No. 148405.) Temperature chart.

tions, and in those doing so only temporarily, there was a stage in which cerebation was slow and sluggish so that it was difficult to elicit answers to questions, or to make the patient coöperate in any way necessary towards the accurate determination of the disturbances of neurological function.

A deep coma or stupor with stertorous breathing and with beginning involvement of the circulation was a matter of grave concern, since it indicated disturbances in the vital medullary centres.

Fever.—A number of the cases developed fever. This was present in the absence of any apparent source of infection. In one case the temperature rose to 106° F.; in another to 109° F.; both of the cases were operated upon but the rise in temperature was independent of the operation. Both of the patients died. I do not believe that the fever was an ante-mortem phenomenon. Two explanations are available: one, that some involvement of the heat centres took place—either primarily as a result of the trauma, or, secondarily, as a result of compression from oedema—which resulted in the extraordinary rise of temperature; or, possibly, some degree of encephalitis followed the contusion of the brain substance. Perhaps this was present in case No. 148405 in which operation demonstrated great intracranial tension and widespread oedema of the brain as evidences of an equally widespread contusion.

General Neurologic Symptoms.—Abnormal neurological phenomena were not always present in the patients in this series; and in 34 of the cases no symptoms or objective signs could be elicited which would indicate any disturbance of neurological function. These were practically always the mild cases, and among them one could distinguish the following: (1) Cases of scalp contusions or lacerations, with trivial or no symptoms and in whom fracture was originally not suspected but subsequently demonstrated by the X-ray in accordance with the routine custom of X-raying all cases of head injury of any kind. These made up the greater number of the "neurologically negative" cases. (2) Patients with such quickly disappearing symptoms that by the time the patients were admitted to the hospital and examined, evidence of any disturbance of neurological function could not be determined. All of these patients recovered, and, on discharge from the hospital, their neurological status was normal.

The remaining patients in this series of cases all presented some abnormality of the normal neurological status. There were all grades of disturbances; some were very mild and were elicited only by examination; others in which the grade of severity reached to a maximum. The effects of these disturbances also varied; in some the abnormalities were transient; in a few the consequences persisted at the time of discharge from the hospital. These effects were seemingly related to the pathology present in the involved area; transient symptoms were associated with localized (relieved) compressions by bone depression or

blood clot, or to temporary disturbances in the circulation, especially on the venous side, as will be pointed out later under the term "longitudinal sinus syndrome"; more lasting or permanent disturbances followed disorganizations of brain tissue due to the provocative trauma or to changes in the blood supply, or to division of major nerve trunks, or to unrelieved conditions (depressions, blood-clots, etc.) which would be apt to result in permanent pathological conditions. Illustrations of these latter conditions will be referred to later.

Concussion.—Twelve of the patients died within a few hours of the accident. It has been assumed that the violent injury had produced a high grade of disorganization of the brain substance sufficient to lead to a rapid death. The clinical pictures included a profound stupor, a high grade of shock, and a condition of the circulation which would have made futile any attempt at operative interference. Frequently there was marked cedema of the lungs within an hour of the injury. In a number there were more or less well-marked focal symptoms. In a few the possibility of an extraordinarily rapid intracranial compression from hemorrhage or cedema with a rapidly fatal involvement of the medullary centres could not be excluded.

Compression Phenomena.—Compression phenomena have been common. They appeared very quickly in most of the cases. An initial stage of concussion was not always present; or, if it were, it could not be distinguished in the severity of the general clinical picture. The cause of the compression was either intracranial hemorrhage, cedema of the brain substance, or both of these. It is very important to be able to recognize those of the cases of compression which are due to cedema—a desideratum which is not always easy of accomplishment—inasmuch as spontaneous recovery without any decompressive or other operation is a possibility. The notes of the following case are given as an illustration:

Hospital No. 191439. A four-year-old boy was brought to the hospital having been picked up on the street. No history of the accident was available. The patient was in deep stupor with noisy stertorous breathing and, altogether, looked very badly. Except for a small laceration of the forehead there was no evidence pointing to the location of the fracture. The pupils were widely dilated, although they still reacted to light, and in the fundi the disk margins were distinctly blurred, especially on the nasal sides. The knee-jerks were hyperactive; otherwise there were no abnormalities. The systolic blood-pressure was 95 mm. Hg, and the diastolic was 65 mm. Hg; the pulse was 68 beats to the minute. There was no doubt that some compression was present, and the signs increased somewhat during the next few hours; nevertheless, a conservative policy was adopted. Twenty-four hours later there was distinct improvement and by the end of the third day the neurological status was normal.

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Whatever compression had been present was surely due to œdema which gradually subsided concomitantly with the return of the normal functions.

In other instances the compressive effects appeared more slowly. In one of the cases the development of the picture consumed three days. This occurred in a seventy-year-old man in whom the accident had resulted in a fracture of the skull, a fracture of the clavicle, and fractures of both bones of the leg. On admission he was in semistupor. There were no objective findings pointing to a focal neurological lesion and no signs of marked intracranial pressure. Signs of the latter, however, gradually grew more prominent during the course of the next three days, at the end of which time the evidences of compression dominated the clinical picture. The patient did not recover.

In judging of the severity of the increase in intracranial pressure the greatest reliance was always placed on the condition of the circulation, especially as indicated in the slowness of the pulse beat, in conjunction with the general condition of the patient and the condition of the eye-grounds. The average systolic blood-pressure found in the patients studied was about 110 mm. Hg, the range being between 90 and 140 mm. Hg; the average diastolic pressure was 73 mm. Hg, the range being from 55 to 100 mm. Hg; the average pulse pressure was 36 mm. Hg. Immediately upon admission the pressure tended to be low, as would naturally be expected from the associated condition of shock; improvement in the general clinical picture accompanied a rise in pressure; a progressive increase or a reappearance of compressive phenomena accompanied a progressive or secondary rise and a terminal fall in blood-pressure.

A marked increase in intracranial pressure has always been considered the most imperative indication for operation and the urgency of the latter was always in direct mathematical ratio with the speed with which the signs of increased intracranial pressure made their appearance and dominated the picture. Every effort was always made to operate before the signs of medullary involvement had made their appearance; any stage, beyond the most early, of compromise of these vital centres creates a situation so serious and grave for the patient as to make any effort towards an operative relief of the compression futile.

Convulsions.—Generalized convulsions were present in one patient of this series. This was a female child of four years brought to the hospital in a comatose condition; no history of the accident was available. The little girl bled profusely from the pharynx and the diagnosis was evident. Generalized convulsions were present and were repeated until the child died forty-five minutes after admission to the hospital. No autopsy was permitted.

Reflexes.—The commonest evidences of neurological disturbance were found in the condition of the reflexes. These existed either alone, or as part of a clinical picture, such as that of a higher focal lesion, in which

the condition of the reflexes was apparently incidental. The response obtained might be equal or unequal on both sides; might be weaker than normal on one or both sides; or might be similarly exaggerated. In a number of the cases the ordinary reflexes could not be elicited immediately upon the admission of the patient to the hospital (*i.e.*, within a very short time after the accident), but very quickly they returned and then they were either normal or followed one of the variations described above. The important point seemed to be that frequently these abnormalities of the reflexes, in the absence of any other evidences of a focal lesion as indicated above, had no definite bearing in the total clinical picture, especially from a therapeutic point of view, and under conservative forms of treatment the patients subsequently made uneventful recoveries. This statement should not be interpreted to mean that these disturbances of the reflexes were mere vagaries which did not reflect any definite pathological lesion in the nervous system; rather, that when these abnormalities were present, lesions must have coexisted which were trivial, and could be recovered from, or could be made good by compensatory effort.

Abnormal reflexes, such as an ankle clonus, a Babinski, a Chaddock, etc., were frequently present. Most often these, too, were part of some larger clinical entity and then they were interpreted as indicating some disorganization in the deeper layers of the cortex or in the subcortical areas. Less often an isolated abnormal reflex, usually a Babinski or an ankle clonus, could be elicited, or the abnormality was associated with some change in the normal reflexes as indicated in the previous paragraph. Here, too, the significance of the changes was not apparent in the total clinical picture, especially as a therapeutic indication; and when no other and more definite indications of trouble were present the usual practice found it wiser to regard these most conservatively. A similar explanation is vouchsafed as was given in the previous paragraph. The notes of the following case are given as an illustration:

Hospital No. 155758. An automobile accident resulted in an injury in the right parietal region of a boy of nine years. There was immediate unconsciousness but no vomiting or external bleeding. The important points in the neurological status included: (1) eccentric pupils which dilated and contracted alternately; (2) absent abdominal and normal cremasteric reflexes; (3) absent knee- and ankle-jerks; (4) bilateral Babinski but no ankle clonus; (5) negative fundoscopic examination. The X-ray showed a Y-shaped fracture in the region of the right parietal bone. Consciousness was rapidly regained and thereafter the boy went on and made an uneventful and perfect recovery.

Eye Symptoms.—In 13 of the cases there were abnormalities in the external and internal ocular apparatus; in 3 of these the pupils were unequal; in one the pupils reacted sluggishly; in 2 there was bilateral deviation of the

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eyeballs; in one there was a paralysis of an extrinsic muscle; in 3 nystagmus was present; and in 3 others there was an exophthalmos.

The bilateral deviation of the eyes occurred in patients with fractures in the parietal portions of the skull; the phenomenon apparently has the same significance as it would have in an ordinary case of apoplexy.

Two of the cases of nystagmus occurred in patients who later developed meningitis; the symptom was elicited while the signs of the latter condition were fully developed and undoubtedly was directly due to it. The third was an irregular nystagmus which was present in a patient with a fracture which involved the mastoid and injured the lateral and transverse sinuses; it very probably was related to some injury of the labyrinth. The results of the total injury were such as to make the operation, which was done, unsuccessful and the patient died.

The cases of exophthalmos were all unilateral. In one case the fracture was in the right occipito-temporal region probably extending into the base of the skull; in the second, there was a left temporo-parietal fracture running downwards into the middle cranial fossa; in both of these the eye on the corresponding side showed a distinct though slight exophthalmos. The third patient had a bad crushing fracture of the skull and malar prominence which had pushed the latter upwards and inwards into the head; the deformity was pronounced and with it was an exophthalmos so extreme as to cause the eyeball to protrude from the orbital cavity for almost an inch. Rockey has recently described these injuries of the malar prominence and recommends the elevation of the fractured portion with a tenaculum forceps—a procedure which is comparatively simple.

In 25 of the patients fundoscopic examinations were made. No abnormality could be discovered in 14; included in these were cases which were "neurologically negative," as well as cases with other signs of disturbed neurological function. The remaining 11 had abnormalities in the fundi, and the latter included the following:

1. Distention of the veins. Two of the cases were "neurologically negative"; the third was a case with an injury of the longitudinal sinus.

2. One of the cases showed distention of the veins of both fundi with a number of hemorrhages immediately near the disk. The fracture was in the mastoid and occipital regions of the skull and was associated with injury of the lateral sinus.

3. There was a well-marked blurring of both disk margins in two patients. One was a case otherwise negative from a neurological point of view. The other was a fracture involving the occipital, parietal and temporal bones; death occurred three days after the injury, the immediate cause of death probably being uræmia.

4. Perceptible papilloedema was present in three patients. In one case there was an extensive fracture, the fissures of which ran on the right and left sides of the vault and into the base; in both fundi the veins

were distended, and in the left there was a beginning choking of the disk. The second case had an injury probably localized to the motor area near the longitudinal sinus, as evidenced by spasticity of all four extremities; in both fundi there was a beginning papilloedema; there were other signs of extensive damage to the brain and a fatal issue followed. The third was a fracture in the neighborhood of the right parietal eminence which extended forward and also downward into the mastoid; injury of the lateral and transverse sinuses was present in addition; a distinct swelling of the disks was perceptible about two and one-half hours after the injury was sustained.

5. One case of fracture of the skull resulted in total blindness. The notes of this case are very interesting:

Hospital No. 172240. The history was that ten days before admission to the hospital the patient had fallen and struck the back of his head. The neurological data included: (1) stupor; (2) tenderness of the skull; (3) moderately dilated pupils which did not react to light; (4) palsy of the right upper lid and of the extrinsic muscles of the right eyeball; (5) blindness; the right disk was normal and there was marked blurring of the left; (6) an absent left knee-jerk; (7) a turbid, bloody spinal fluid under increased tension. The X-ray demonstrated a T-shaped fracture through the vertical portion of the frontal bone involving both the right and left sides. A subtemporal decompression was done in the hope of saving the eyesight; the operation was, however, unsuccessful and the patient left the hospital totally blind.

Discussion has centred about the possibility of a papilloedema making so rapid an appearance after injury of the skull and of the intracranial contents; the possibility has even been denied absolutely. Our own experience has been of an affirmative nature; not only do we believe that a papilloedema can occur, but we are accustomed to make use of this phenomenon, whenever it may be present, as an important criterion in the summing up of the total clinical picture, especially for its value as a therapeutic indication.

This experience is not in mathematical accord with that reported by Kearney, who made his observations on Sharpe's cases. Kearney finds some oedematous blurring of the disks in all cases of fracture of the skull, which is present during the first twenty-four hours after the injury, which retrogresses in those whose symptoms improve and disappear, and which grows more marked if signs of intracranial compression become apparent and increase. In our own cases the occurrence of blurring, or of actual swelling of the disks, has been present in a minority of the cases only.

Focal Neurological Symptoms.—Focal neurological symptoms, whenever they could be elicited, naturally made the most conspicuous and impor-

tant element of the entire clinical picture. They were present in 16 of the patients. In most of these the signs of the focal lesion were immediately apparent on the first examination; in the others the development of the objective findings was more gradual. In one patient focal symptoms developed a fortnight after the accident.

Cranial Nerves.—Involvement of the cranial nerves was present seven times. In two of the cases the orbital nerves were involved; one of these was the case of total blindness (*vide supra*) with which there was associated paralysis of the extrinsic muscles of the eyeball and a palsy of the upper lid. This was a permanent result.

In five other cases the facial nerve was involved. In two of these the facial paralysis formed part of a total hemiplegia. In the other three cases the facial palsy existed alone. In one of the latter there was a fracture of both parietal bones parallel to the coronal suture; the paralysis involved all three branches and was still present when the patient left the hospital. In the second the X-ray showed a fissure in the frontal region; the palsy was present in all three branches and was associated with active knee-jerks and a one-sided ankle clonus. The paralysis persisted until after the patient's discharge from the hospital. The third was the parieto-occipital fracture, described subsequently, which developed a meningitis from which the patient recovered; the palsy was present before the signs of meningitis developed and persisted as a permanent effect. No one of the latter three cases was subjected to operation and except for the local paralysis perfect recoveries were made.

Focal Symptoms in the Extremities.—In two of the patients the symptoms were limited to one upper, and in one other patient to both upper extremities. There was no case of actual paralysis; instead we were fortunate enough to find only irritative phenomena. In one of the cases there was marked rigidity of one entire upper limb with a diminution of all the reflexes; in addition there were signs of a marked increase of intracranial pressure. An exploratory craniotomy showed a fracture extending backwards from the parietal to the occipital bone and downwards into the base, and a large subdural clot with the brain under great tension. The patient died within six hours of the operation. The second of the patients was admitted to the hospital two weeks after an injury in the right occipito-parietal region with the story that two days previously (*i.e.*, ten days after the accident) the patient had passed gradually into a comatose state and had developed twitchings in the left hand and forearm. These were quite marked while the patient was in the hospital and in addition he exhibited disturbances of the normal reflexes, and some abnormal reflexes rather irregularly distributed; the fundi were normal. A right subtemporal decompression was done and directly in the exposed area was a large subdural clot and disorganized brain tissue. Progressive improvement began two days later and, on discharge from the hospital, all the neurological disturbances had disappeared. In the

third patient an injury was sustained in the right occipito-parietal region which resulted in spasticity of both upper extremities with exaggerated reflexes in the upper, and inhibited reflexes in the lower, extremities; a marked Babinski on the right, and a slight bilateral ankle clonus were also present. Operation was done immediately and a flap was turned down in the right subtemporal region extending backwards towards the occiput. A large fissured fracture was present in the parietal bone running downwards into the auditory canal, with some depression, and with tearing of the lateral sinus. The operation did not yield a successful issue.

Signs of cortical irritation were present in a fourth patient and were located in both the upper and lower extremity of the same side. The patient was comatose. There were no external evidences in this case pointing to any definite location as the site of the injury, but there was constant twitching in the left upper and lower extremity. The left side was hypertonic with exaggerated reflexes; the right side was hypotonic with diminished reflexes; a bilateral Babinski could be demonstrated. Some very serious and mortal injury existed here, as was evidenced by the findings, by the general condition of the patient, and by the widely dilated pupils, but, nevertheless, a bilateral craniotomy was done over both motor areas, which showed (1) a fracture of the left vault; (2) rupture of the left middle meningeal artery; (3) subdural and subarachnoid bleeding with brain laceration; and (4) bloody cerebrospinal fluid under great tension. The fatality which followed was to be expected.

Hemiplegia.—There were 4 cases in this series in which the dominant symptom was a hemiplegia. One of these is the case described subsequently under vessel injuries (No. 152653). The notes of the other cases follow:

Hospital No. 188349. The patient, a child of nine years, was struck over the head with a milk bottle six hours before admission to the hospital. He immediately became drowsy and complained of headache. On admission the physical findings were (1) a hæmatoma in the parietal region; (2) exaggerated knee- and ankle-jerks; (3) a right-sided ankle clonus; (4) normal fundi; and (5) bloody spinal fluid. Twenty-four hours later the neurological status included in addition (6) pronounced weakness of the left side of the body; (7) some spasticity of the right lower extremity with a Babinski. A left subtemporal craniotomy was done then which showed increased tension of the intracranial contents; an intact dura; and a large extradural hemorrhage. When the clots were cleared out the brain pulsated well and the dura was therefore not opened. The patient died six hours after operation.

Hospital No. 161336. One hour before admission to the hospital the patient had fallen down an elevator shaft. The physical examination showed (1) a semiconscious patient in marked shock; (2) a large hæmatoma in the right parieto-temporal region; (3) bleeding from the right ear; (4) a complete left hemiplegia; (5) immediate loss of all reflexes which began to return shortly; thereafter the left reflexes were

all exaggerated, there was a left inexhaustible ankle clonus, and a right-sided exhaustible clonus; (6) signs of compression, the pulse dropping down to 44 beats per minute; (7) distention of the vessels of both fundi with hemorrhages. Operation was done four hours after admission; the depressed fracture ran from the mastoid and temporal bones to the occiput; the dura was plum-colored and there was a perforation of the lateral sinus; extensive hemorrhage was associated with laceration of the brain. A contralateral decompression was done in addition.

Twenty-four hours later there was considerable improvement; motion returned in the left upper extremity. On the next day, however, conditions were much worse; the temperature rose to 107° F. and the patient died.

Hospital No. 154449. The forty-nine-year-old patient fell downstairs for a considerable distance about nine hours previous to his admission to the hospital. One hour afterwards unconsciousness supervened, gradually deepened to coma, and persisted. The pupils were contracted; a left-sided external strabismus was present and the right side of the body was apparently paralyzed; the reflexes were absent. Bilateral subtemporal decompression was immediately done; it disclosed increased tension of the brain on the left side and a moderate sized subdural hemorrhage on the right side. No improvement followed; the patient's general condition remained unchanged for the following three days, and at the end of that time he died.

Longitudinal Sinus Syndrome.—In 1915 Holmes and Sargent described over 70 cases of war injury of the longitudinal sinus in which a characteristic symptomatology was observed. As pointed out by Cushing this syndrome has its counterpart in the traumatic spastic paralysis of childbirth—the so-called Little's disease. Since the communication of Holmes and Sargent additional cases following war injuries have been described by Cathelin and by Cushing. Briefly stated the injuries were gutter or tangential skull wounds, or blows through an intact helmet which resulted in fracture with compression or laceration of the longitudinal sinus or of some of its anastomotic branches in the neighborhood of the motor cortex. Frequently the paracentral lobules and the convolutions bordering the fissure of Rolando showed injuries in addition. Thrombosis of the sinus, or of the large superficial cortical veins emptying into it in the area of involvement, were frequently, though not always, found.

Symptomatically there were two groups of cases, the essential part of both being a spastic paraplegia involving both lower extremities symmetrically or asymmetrically; or the paralysis was more extensive in the order in which the motor centres are grouped in the cortex from the superior margin of the cerebrum downwards towards the fissure of Sylvius, and corresponded with the extent of the brain damage from the vertex of the skull downwards on both sides. The differentiation of the

two groups was made by the presence or absence of a sensory ataxia. This differentiation was emphasized more strongly by Cathelin in 1918.

The essential element of the paralysis is the extreme rigidity. Holmes and Sargent used this point in distinguishing this syndrome from that ordinarily seen with cortical paralyses; in the latter they point out that after a transient stage of rigidity the limbs lie flaccid for a period usually about ten days in length, in which time the reflex irritability is inhibited.

In this syndrome pain and temperature perceptions are unaffected and the tactile sensibility is not perceptibly diminished. The discrimination of compass points and the deep muscular sensibilities—*i.e.*, the recognition of the position and of passive movements of the limbs, and the recognition of the form of objects—can show marked abnormalities. These sensory disturbances were found to be most common when the injury was some distance behind the Rolandic fissure.

The symptoms need not necessarily be permanent and Holmes and Sargent point out that when the thrombosis in the cortical veins is not too extensive, it is possible for a collateral circulation to be established sufficient to cause a gradual disappearance of the symptoms.

In 6 of our cases this syndrome was present. The notes of the cases follow:

CASE I.¹—A sixteen-year-old lad was kicked in the head by a horse. There was a scalp wound one inch behind the fronto-parietal suture near the mid-line. No alarming symptoms were present and the injury was considered a triviality. Four days later a progressive weakness of the right arm and leg began to develop. Two days later the physical examination showed the following: (1) cracked-pot percussion over the parieto-temporal region; (2) slight rigidity of the neck; (3) slight swelling of the veins of both fundi; (4) almost complete paralysis of the right arm and leg with exaggerated reflexes; a bilateral Babinski and ankle clonus and a Kernig were also present; (5) marked spasticity of the right leg; (6) fair power in the left leg; (7) less spasticity of the left than of the right leg with a similar condition of the reflexes; (8) a spinal fluid under moderate pressure which was otherwise negative.

Operation was done on the sixth day after the injury. The craniotomy over the site of the injury disclosed a bone fragment of the comminuted fracture depressed for one-half inch below the surface and lying across the longitudinal sinus; the considerable hemorrhage, which occurred on removal of the fragment, was easily controlled by muscle tissue. There was no dural injury. After proper toilet of the wound, the fragment was replaced and the wound was sutured without drainage. Improvement in the signs and symptoms began twenty-four hours after operation, persisted and became progressive, and, on discharge from the hospital, the patient's neurological status was normal.

¹ Private records of Dr. Elsberg.

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CASE II (Hospital No. 183366).—A flying brick striking the head of this boy of eleven years caused a compound depressed fracture in the midline at approximately the junction of the parietal and occipital bones. The dominant neurological findings included spasticity of both lower extremities with increased, but no abnormal, reflexes. The child was in very bad condition and operation was done mostly to properly cleanse the wound. The fracture was comminuted and markedly depressed and overlay the longitudinal sinus; numerous fissures passed forwards and backwards and across the midline. A small portion of the cortex was exposed through a lacerated dura. One bone fragment was imbedded in the longitudinal sinus; on freeing this a furious hemorrhage occurred which was controlled with difficulty. The child died three hours after the operation.

CASE III (Hospital No. 153545).—The patient, a boy of seven years, was hurt in an automobile accident just prior to his admission to the hospital. An immediate examination showed the following: (1) stupor and marked restlessness; (2) a hæmatoma in the left parietal region; (3) deviation of the eyes to the right; (4) a left complete facial paralysis; (5) marked spasticity of the lower extremities with short jerky movements and with the feet in an equinus position; (6) exaggerated knee-jerks, the right being more marked than the left; (7) abnormal reflexes on both sides—Babinski, Oppenheim, Mendel, etc. Two days later the spasticity had lessened but otherwise there was little change; the stupor continued. Operation was proposed but was refused and the patient was removed from the hospital. An X-ray examination showed a transverse fracture in the parietal portion of the skull, longest on the left side and near the coronal suture.

CASE IV (Hospital No. 179660).—This little girl of six years was thrown from an automobile. There was a swelling over the right mastoid; a second swelling over the occipital protuberance; a third over the left parietal region. The neurological findings included (1) unequal pupils which did not react to light; (2) a beginning papilloedema; (3) right internal rectus palsy; (4) spasticity of all four extremities; (5) absent abdominal reflexes; (6) exaggerated knee-jerks and positive Babinski, Gordon, and Oppenheim reflexes; (7) peculiar athetoid movements of the hands with complete flexion of the hands at the wrists; (8) coma. The temperature was 104° F.; the breathing had Cheyne-Stokes characteristics; compression signs were very marked; and the general condition rapidly became very bad. Just before death the spasticity had disappeared, the reflexes were abolished, and the pupils were unequally dilated.

CASE V (Hospital No. 180991).—The patient, a child of nine years, was struck by an automobile. The neurological status included (1) unconsciousness with Cheyne-Stokes breathing; (2) unequal pupils which did not react to light; (3) marked spasticity of all four extremities; the hands are described as having "peculiar contractures"; (4) hyperactive reflexes. The general condition of the patient was very bad and death occurred four hours after the injury.

CASE VI.²—A boy of eleven years was struck by an automobile on the left side of the head. The immediate findings included (1) stupor; (2) deviation of the eyes to the left with pupils that reacted to light; (3) except for some slight increase of the reflexes on the right side, no abnormality in the upper extremities; (4) lively right abdominal and absent cremasteric reflexes; (5) marked spasticity of the right lower extremity so that the leg is bent with difficulty and the reflexes are not elicitable satisfactorily on account of the spasm; (6) a less spastic condition of the left lower limb with exaggerated reflexes and an ankle clonus; (7) bilateral Babinski; (8) practically negative fundoscopy; (9) a large hæmatoma in the parietal region. From the symptoms it was predicted that the lines of fracture would cross the median line of the skull and the longitudinal sinus and so the X-ray showed the injury.

A week later the symptoms were all much better.

I add the notes of a seventh case which probably belongs with this group.

CASE VII (Hospital No. 177039).—A thirty-three-year-old man fell from a ladder a distance of six feet and landed on his shoulder and side of the head. A period of unconsciousness was followed by improvement in the mental state. The findings included (1) a hæmatoma over the right parietal region; (2) dilated pupils which reacted; (3) irregular nystagmus with lack of coördination of the extrinsic muscles; (4) spasm of the right shoulder; (5) exaggerated knee-jerks and a beginning left ankle clonus. Twenty-four hours later the patient was again deeply unconscious and the findings now included the following: (6) widely and unequally dilated pupils with marked distention of the veins of the fundus and later a definite papilloedema; (7) rigidity of the lower extremities with exaggerated and unequal reflexes. The X-ray showed a fracture running downwards from the parietal eminence towards the mastoid and in a forward direction from the latter.

A bilateral subtemporal decompression was then done. The lateral and transverse sinuses were found lacerated and the bleeding was controlled by packing and muscle tissue. The patient died within an hour of the operation.

This case is included here inasmuch as in all probability there co-existed an injury to the longitudinal sinus which was not demonstrated at operation.

All of our cases in this group had the injury in the general neighborhood of the vertex of the skull and the fractures involved the parietal bones alone, or the parietal and occipital bones near their mutual junction. Two of the fractures were compound. In all, except one, the symptoms were practically immediate. In the exception the symptoms gradually developed over a period of two days and began four days after the injury.

The general symptoms of brain injury were well marked. In two of the patients these indicated such a severe injury as to make any oper-

² Private records of Dr. Elsberg.

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ative interference unjustifiable and these died shortly after admission to the hospital. In four of the patients the degree of stupor or coma precluded the possibility of a complete sensory examination so that we are unable to make any differentiation based on sensory grounds, such as was made by Holmes and Sargent and by Cathelin. Case VI demonstrated how these symptoms might be temporary; in this case improvement in the symptoms and objective findings began several days after the injury. This corresponds with the rather rapid improvement noted in one of Holmes' and Sargent's cases.

There was no thrombosis to be seen in the two cases subjected to operation. There was, however, marked depression of the fragments with compression of the sinus which interfered with the flow of blood, as well as some damage to the adjacent cortex.

Three of the patients in the longitudinal sinus group died, one following, and two without any, operative interference. One patient improved spontaneously; another made a perfect recovery after operation; in the last case the final result is not known because the patient was removed from the hospital against advice. Our mortality was rather high for these patients—about 60 per cent. This is higher than in the results reported by Cushing for the military cases, which was 30.7 per cent. We believe the difference in our cases to be due to the severity of the initial trauma.

COMPLICATIONS

Vessel Injury.—Intracranial hemorrhage as demonstrated at operation was a frequent accompaniment of the fractures in our cases. The source of the bleeding was (1) the meningeal vessels, (2) the contused or lacerated brain, (3) the venous sinuses, or (4) combinations of these sources. Undoubtedly in the remaining unoperated cases more or less hemorrhage was frequently present but its amount was not sufficient to demand any interference or even to call forth any indicative symptoms.

The symptoms, when present, were either those of a general intracranial compression, or indicated a disturbance of function in a localized portion of the brain; in some of the patients there were initial focal symptoms followed more or less quickly by the signs of general compression. In the cases with focal symptoms the diagnosis of hemorrhage was frequently a supposition based on empiric grounds, inasmuch as similar symptoms might very well occur with a localized disorganization of brain tissue. The notes of the two following cases are given as illustrations:

Hospital No. 152653.—A thirty-nine-year-old man fell from his truck and, although he landed on his head, was able to walk to the hospital, where he complained chiefly of headache and dizziness. Shortly thereafter he fainted and went into stupor, and the latter alternated with short periods of consciousness. The essential symp-

toms included a left hemiplegia and the signs of a progressing intracranial compression. The operation which was done within two hours of the injury showed an extensive stellate fracture into the base with depression of the fragments, and a large extradural hemorrhage. The clot was cleaned out and, after the bleeding had stopped spontaneously, the cavity was drained by a gauze strip and the outer wound was sutured. The immediate good effect of the operation persisted and became progressive.

Hospital No. 148405.—In contradistinction to the previous case this patient, a boy of nine years, was brought into the hospital in a stuporous condition with the history of an injury to his head. The dominant symptoms in this case also included the signs of a marked increase of intracranial pressure with a parietic condition of the left side of the face and convulsive seizures in the left upper and lower limbs. The exploratory craniotomy did not disclose any hemorrhage, but a brain exceedingly tense with œdema, indicating that the brain was badly contused. No improvement followed the operation, death following shortly thereafter.

Compression phenomena resulting from œdema more commonly result relatively slowly, and, usually, several days follow before the evidences are fully developed. For this reason it is good practice to carefully watch the variations in the pulse and respiration, and whatever changes may occur in the fundi, for several days after any head injury. Less commonly consecutive to a cerebral trauma œdema occurs very rapidly; a good example of the latter is the acute œdema which occasionally follows operative interference for the removal of brain tumors.

Injuries of the venous sinuses have proven themselves to be complications of extraordinary gravity. The condition was found five times in this series of cases: on two occasions the longitudinal sinus was found torn; in two other cases the lateral sinus was lacerated or perforated by a bone spicule; in another case the lesion was in the lateral and transverse sinuses. In all of these cases, except one, the clinical picture on admission to the hospital was that of an advanced grade of intracranial compression and immediate operation was deemed imperative; in all extensive hemorrhage was found. There was often associated a comminuted and depressed fracture and on exposing the injured area the opening in the sinus was found to be partially, or entirely, occluded by one of the fragments. In several of the cases the sinus injury was not anticipated and on elevating or removing the fragments a profuse hemorrhage flooded the wound. The best way of controlling the bleeding, however profuse it may be, was by applying over the rent a sufficiently large piece of muscle or fascia and holding it in place by pressure with a sponge for a few minutes. Ortali accomplishes the same purpose by making use of a pediculated flap of aponeurosis from the immediate neighborhood. The general principle of both of these procedures was

first recommended by Horsley many years ago since which time it has been employed very often.

In the exception noted in the last paragraph (*vide* Case I, under "Longitudinal Sinus Syndrome") the immediate symptoms were trivial and alarming symptoms necessitating operation appeared six days later; this was the only case of sinus injury in our series which recovered. All of the remaining cases with this complication terminated fatally within a comparatively few hours after the operation. Injuries of the lateral sinus seem to carry with them a much graver prognosis than those of the longitudinal sinus. Corroboration of this statement is found in the cases of war injuries studied by Velter; in the latter's series there were three cases of lateral sinus injury with two deaths and four cases of longitudinal sinus injury with one death.

Leakage of Cerebrospinal Fluid.—Two important conditions which complicate fracture of the skull are directly associated with compound fractures communicating with the skin, the naso-pharyngeal space, or the middle ear. In two of the cases there was a profuse leakage of cerebrospinal fluid through the external wound. The phenomenon, however, did not lead to any extraordinary symptoms; a meningitis did not arise; and the patients made uneventful recoveries. One of the cases had a compound fracture through the frontal bone. The other had a fracture of the petrous portion of the temporal bone the fissures of which extended through into the middle ear where the drum-head had been torn; the discharge of cerebrospinal fluid continued for eight days, and thereafter the opening in the drum-head closed spontaneously.

Meningitis.—A complicating meningitis was encountered four times. Twice the fracture ran through the frontal bone into the nose by way of the frontal sinuses; once the fracture passed through a suppurating middle ear. In two of these we have bacteriological studies indicating that the responsible organism belonged to the pneumococcus group. In the middle ear case the fracture could not be demonstrated by the X-ray; it was, however, easily seen post-mortem. All of these terminated fatally.

One case of meningitis complicating an occipito-parietal fracture recovered. The notes of this case are as follows:

Hospital No. 154616.—A young woman of twenty-one years, having fallen from a street car, landed on the back of her head. She vomited frequently thereafter, and was very restless, and bled slightly from the nostril. On admission she was conscious, had no paralysis of the limbs but a distinct weakness of all three branches of the left facial nerve; the normal abdominal reflexes were exaggerated on the right side; there was a Babinski, an Oppenheim and a Gordon reflex on the right, and an exhaustible ankle clonus on the left side. The fundi were negative. There was a laceration of the midoccipital region with a large hæmatoma.

Twenty-four hours later there was marked rigidity of the neck with a bilateral Kernig and the patient was irrational. A lumbar puncture showed the spinal fluid to be bloody and under considerable pressure; on subsequent puncture the fluid was yellow. The symptoms continued and on the fifth day the disks showed a distinct papilloedema. Three days later the symptoms began to disappear; thereafter the improvement became progressive; and on discharge from the hospital the facial paralysis was the only abnormality present.

We have been struck by the fact that the two cases of cerebrospinal fluid leakage did not lead to a meningitis. The same immunity to infection seems to be present in other somewhat analogous cases in which a free escape of cerebrospinal fluid takes place. There was one patient with a paravertebral abscess which had been properly incised and drained. Several days later it was noted that cerebrospinal fluid was escaping from the wound. In spite of the fact that the entire environment of the fistula was thoroughly infected, no meningitic symptoms ever developed and the boy made an uneventful recovery. A similar accident occasionally follows operations upon the brain. The post-operative leakage of cerebrospinal fluid may be moderate or profuse and persists for a comparatively long period before the fistula in the scar closes. Infection, however, occurs with extreme rarity.

We have been equally struck by the absence or escape of cerebrospinal fluid in the compound fractures which were complicated by a diffuse meningitis. That the dura is not always torn was demonstrated in some published post-mortem examinations (Schmidt). In these cases contusions of the dura mater with microscopical lacerations, or the traumatic conversion of an area in direct relationship with an infected locality into a *locus minoris resistentiæ*, would furnish a sufficiently plausible mechanism for the occurrence of the meningitis. On the other hand, great numbers of gunshot wounds have been reported (Hartmann, Mueller, Fraser, Sargent and Holmes, Cushing, etc.) in which the dura was found to have been opened widely; and the absence of comment indicates that these were not complicated by the escape of cerebrospinal fluid; some of these later developed meningitis. The explanation of this phenomenon is not quite apparent: possibly there is a reflex inhibition of the flow of cerebrospinal fluid; or the nature of the injury is such as to encourage in some of the patients an extraordinarily rapid agglutination of the pial surfaces surrounding the area of involvement. The last explanation is extremely theoretical inasmuch as in actual practice it is extremely difficult to promote the formation of adhesions of the pia-arachnoid.

Icterus.—An unusual complication occurred in one of the cases of meningitis which followed fracture of the skull: an icteric condition of the skin appeared in a child of nineteen and one-half months with a

fracture of the frontal bone while the signs of meningitis were at the maximum. The child died three days after the injury was sustained.

TREATMENT³ AND INDICATIONS FOR TREATMENT

Compound Fractures.—It has never been considered an absolute rule to make use of this complication as an imperative indication or as a convenient excuse for operating upon the fracture itself. When no other compelling symptoms or objective findings were present, the outer wound was cleansed in the proper surgical manner and was sutured, and most often healing took place by primary union; the fracture itself was not disturbed. Infection of the bone very rarely took place; a rigidly conservative treatment was then practiced and always healing took place after a small superficial scale of bone had sequestered out. In a general way this plan of treating the local wound, which was practiced even before the war, corresponds very well with the local treatment of the war wounds, the so-called “débridement,” so widely emphasized by the military medical men.

Craniotomies.—According to the symptoms exhibited the patients who were operated upon were subjected to a unilateral or bilateral subtemporal decompression, to a unilateral or bilateral exploratory craniotomy, or to an exploratory craniotomy plus a contralateral subtemporal decompression.

The method of making the subtemporal decompression followed that described by Cushing; the essential steps included splitting of the temporal fascia and muscles in the direction of the fibres, the subperiosteal removal of that portion of the skull lying directly underneath, and the opening of the dura mater. We do not consider it to be sufficient to remove a small segment of the skull; the minimum that we recognize as a decompressive opening is a fenestra 5 by 6 cm. in diameter and frequently we make them much larger.

A number of the craniotomies have been flap operations. They were made over the area suspected and the bone-flap turned down was sufficiently large to enable one to work with ease; as a general rule, the bone-flap was replaced at the close of the operation and the outer wound was sutured without drainage. Of necessity these were mostly exploratory operations. In other patients the procedure was carried out primarily as a flap operation; during the manipulations the advantageousness of a decompression was recognized and at the close of the operation the bone-flap was removed in order to accomplish this desideratum. This was only advisable when the flap had been fashioned in the temporal regions; otherwise it seemed wiser to do a contralateral decompression in the usually approved manner.

³ The various operations in this series of patients were performed by Doctors Elsberg, Taylor, Brickner, and Wilensky. Case No. 172240 was operated upon by Doctor Buerger.

In the remaining operated patients operation was done for depressions of various kinds. In some it was simply to insert a hook and elevate the depressed fragments; in others it was necessary to use more energetic measures, and a very good way was to cut a fissure directly through the entire depressed area with a bone-cutting forceps and then to elevate each half separately. In any case the procedure followed general surgical principles.

When the dura was found torn the opening was utilized, when conditions called for it, for exploratory purposes. At the conclusion of whatever manipulations were found necessary, the laceration in the dura was repaired by suture. If the necessary "débridement" resulted in a dural defect the latter was made good by a plastic operation or by the use of cargile membrane. An intact dura was never incised except in the presence of evidence of subdural injury and hemorrhage, or when a decompressive effect was desirable. Drainage through the dura was never employed.

Lumbar Puncture.—In no one of the cases in which lumbar puncture has been practised has it seemed to give any added information which would be of value in the comprehension of the clinical picture; nor did it subserve any useful function from a therapeutic point of view. Certainly when the intracranial pressure was very high it had no decompressive effect and other measures were necessary to obtain efficient diminution of the compression.

In studying cases of crushed or fractured skull following war injuries, LeRiche found that the cerebrospinal fluid was as often clear as sanguineous and that he could never draw any certain conclusions, inasmuch as about 16 per cent. of the pure scalp wounds were associated with colored spinal fluids. Nor could he extract any useful information from studying the pressure of the spinal fluid. Chemical and cytological examinations of the fluid also yielded no pertinent facts. LeRiche found, however, that repeated lumbar punctures exhibited good therapeutic effects in these war wounds. Similar good effects were noted by Alhaique. Albert has also noted such good effects, and, in addition, lumbar puncture has proved, for him, an efficient method of diagnosis in doubtful cases.

The experiences of Cushing and of Gray, as regards the therapeutic effect of lumbar puncture, are more in conformity with our own. Cushing regards it as a palliative measure which affords but a very short period of relief. Gray has found the procedure useful sometimes in relieving the general evidences of pressure, but just as often the lumbar puncture fails to have any effect. Possibly our own experience has been due to the fact that we have not been very persistent with this form of therapy, for the reason that in those cases in which it might have been applicable it seemed much better judgment to us to operate and procure an immediate, an efficient, and a permanent relief of the compression, rather than be content with a palliative measure which, under the best circum-

stances, would yield only a temporary relief, and which might fail at a critical moment.

Weed and his co-workers have pointed out that the withdrawal of cerebrospinal fluid through a lumbar puncture can, in the presence of some infective focus in the body, be followed by a meningitis. These conclusions were based on grounds entirely experimental, the essentials of which include an artificially induced bacteriæmia followed by a lumbar puncture. Lumbar puncture has been done numberless times for war fractures of the skull with and without injury of the intracranial contents and in the presence of infection, and up to the present no case has been reported in which the indicated accident has taken place. However, in contradistinction to these traumatic cases, Wegforth and Latham, in writing of their experiences during the recent epidemic, report five personal cases and refer to others in the literature in which the release of cerebrospinal fluid by lumbar puncture in patients with bacteræmias, was followed by meningitis. The five personal cases reported occurred in meningococcus infections. It is well, therefore, for one to be on the lookout for such a contingency.

RESULTS

Immediate Results.—Of the 72 cases in the series 22 patients died, making a total mortality of 31 per cent. Eighteen of the patients were operated upon and of these 6 died—a mortality for the operated cases of over 48 per cent. Of the total number of fatal cases 36 per cent. were operated upon. Of the remaining cases, which were treated conservatively, 14 died—a mortality of almost 27 per cent. Subtemporal decompression was done 8 times; 5 of these died, 2 recovered completely, 1 was unimproved. Craniotomy alone was done 7 times; 2 of these made recoveries and the remainder died. Craniotomy with contralateral decompression was done in 3 cases with 2 deaths.

In comparison with these the statistics published by Mixter of Boston showed the following results: General mortality, 54.1 per cent.; operative mortality, 43.4 per cent.; mortality after expectant treatment, 58.3 per cent. In our series there were much better results following the conservative plan of treatment; and it is rather curious and very interesting to note how closely the mortality figures of the operated cases approached one another in the two series of cases.

The most important reason for the high mortality of the cases operated upon is probably the nature of the original injury, or some extraordinary condition complicating the primary lesion. We do not believe that operation, done skilfully and under good conditions, adds anything to the risk, or the final result. A glance through the case reports of this communication will corroborate this statement.

In summing up our results from the point of view of the neurologist

in so far as they may have bearings on the indications in any future case, it seems:

1. That conservative and expectant methods of treatment, whenever they can be safely employed, yield the best results. We are unalterably opposed to operating indiscriminately upon every case of fracture of the skull. It seemed to us that as the cases presented themselves for treatment they naturally fell into one of three groups: (a) A large group the members of which always recovered spontaneously; (b) a smaller group the individuals of which were almost certain to die with or without operative treatment; (c) a very small group in which the individuals presented such border-line evidence of intracranial damage as to make a policy of watchful expectancy advisable, but for whom we were constantly in readiness to operate at a moment's notice; the final outcome in these cases was always doubtful.

2. Operation is imperative in every case showing the signs of an advancing intracranial pressure. Operation should be done in the early stages before there is evidence of medullary involvement.

3. Irritative or paralytic focal symptoms pointing to pressure upon or disorganization of definite cortical areas are the next most important indications for operative interference. Isolated or irregular disturbances of neurological function can be discarded and for these conservative forms of treatment will yield superior results; seemingly these abnormalities have no important therapeutic bearing in the total clinical picture.

Late Results.—It has been possible to obtain reports of the late results in 13 of the patients. The periods of time which have elapsed since discharge from the hospital average up to two years. Of these 13 patients 3 were subjected to operation and the remaining 10 made spontaneous immediate recoveries.

Of the unoperated cases two are perfectly well and there are no signs or symptoms pointing to any neurological disturbance. Three patients have generalized or localized headaches, and in two others the headache is associated with dizziness; one patient has spells of dizziness alone. These symptoms are not severe, make their appearance at rather infrequent intervals in most of the patients, and do not incapacitate the patients in any way for their routine work. One patient vomits occasionally; it is difficult to connect the symptom with any neurological lesion, and it is equally possible that it is the manifestation of some temporary gastro-intestinal disturbance.

At the present writing there is evidence in two cases of permanent focal neurological abnormalities. The first patient is a boy of eight years in whom one of the fissures of a stellate fracture in the right parieto-temporal region extended into the external auditory meatus. During the stay of the patient in the hospital the neurological status was normal and a similar condition persisted at the time of discharge. At the time

of the last report—two years after the injury—hearing in the right ear is diminished approximately one-half. There is no history of there ever having been any disease in the middle ear. In a discussion of the ear complications of fracture of the skull, Fraser, quoting Brun, notes that disturbances of hearing follow in 14 per cent. of all skull injuries and in 24 per cent. of basal fractures.

The second is the hospital patient No. 172240, in whom a frontal bone fracture was associated with blindness; although no further report is available we assume that the blindness is a permanent defect.

Epilepsy, either general or of the Jacksonian type, has not developed in any of the patients we have been able to follow.

The three patients who were subjected to operations are, up to the present writing—between one and one and one-half years—perfectly well and their neurological status is normal. One of these is the hospital patient No. 186858 described above; the second is the first case of those described under the “Longitudinal Sinus Syndrome.” The third is a young child of fourteen months who had sustained a fracture at the inferior angle of the parieto-occipital junction. The operative findings included a depressed fracture, an epidural clot, laceration of the dura, and traumatized brain tissue; the bone depression was cut away, leaving an exposed area the size of a silver dollar; uneventful healing followed.

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GUNSHOT FRACTURES OF THE HUMERUS TREATED BY SUSPENSION AND TRACTION

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A STUDY of the results obtained by different methods in the treatment of war wounds is necessarily obscured because of such variables as extent of the original injury and delay in hospitalization, but more especially because it is impossible to carry out the treatment from start to finish in any single hospital. With these difficulties in mind, it is the purpose of this paper to review the cases of gunshot wounds of the humerus treated in the service of Colonel Joseph A. Blake at American Red Cross Military Hospital No. 2, where the method of suspension and traction as developed by Colonel Blake has been carried out.

The hospital was opened May 2, 1917, as an institution for French wounded, and although militarized November 1, 1917, did not receive American wounded in large numbers until June, 1918. During this period its status was that of a base hospital receiving patients from several days up to several weeks after wounding, and evacuating them in a leisurely manner. During the summer and early fall of 1918, it served both as evacuation and base hospital; from then on until closing, January 31, 1919, it resumed its original character of base hospital. The result of the intensified demands of the summer months was the reception of a large number of early cases who had had long transportation without previous treatment; and also enforced evacuation of many cases who would have been otherwise retained.

Under these circumstances, our statistics have to bear, in part, the brunt of evacuation hospital problems such as gas gangrene, and also base hospital problems such as prolonged sequestration and delayed union. French patients continued to be received in small numbers up to the closing of the hospital, but almost always after previous hospitalization, so that a comparison between the two series shows, for instance, an absence among the French of those grave infections which do not pass the evacuation hospitals.

It has been the policy to retain cases of fractured humerus if possible until union was established. If circumstances do not permit this, we have preferred to forward at once, those of them who are in good condition, to the place where they will receive their definitive treatment. This series therefore contains a number of early cases in good condition who remained only a day or two. It also contains a considerable proportion of cases who were evacuated as soon as, or shortly after, union had become established. On the other hand, there are some who were received after the average period required for union.

Gunshot fractures present not only the problem of the fracture, but also that of the wound, which means infection in a considerable proportion of

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cases. We believe that suspension and traction, without a fixed splint, meets both problems better than any other method for the treatment of compound fractures of the humerus.

The method has already been described in the publications of Colonel Jos. A. Blake^{1, 2, 3} and Major Kenneth Bulkley,² so that a brief résumé only will be given (Fig. 1).

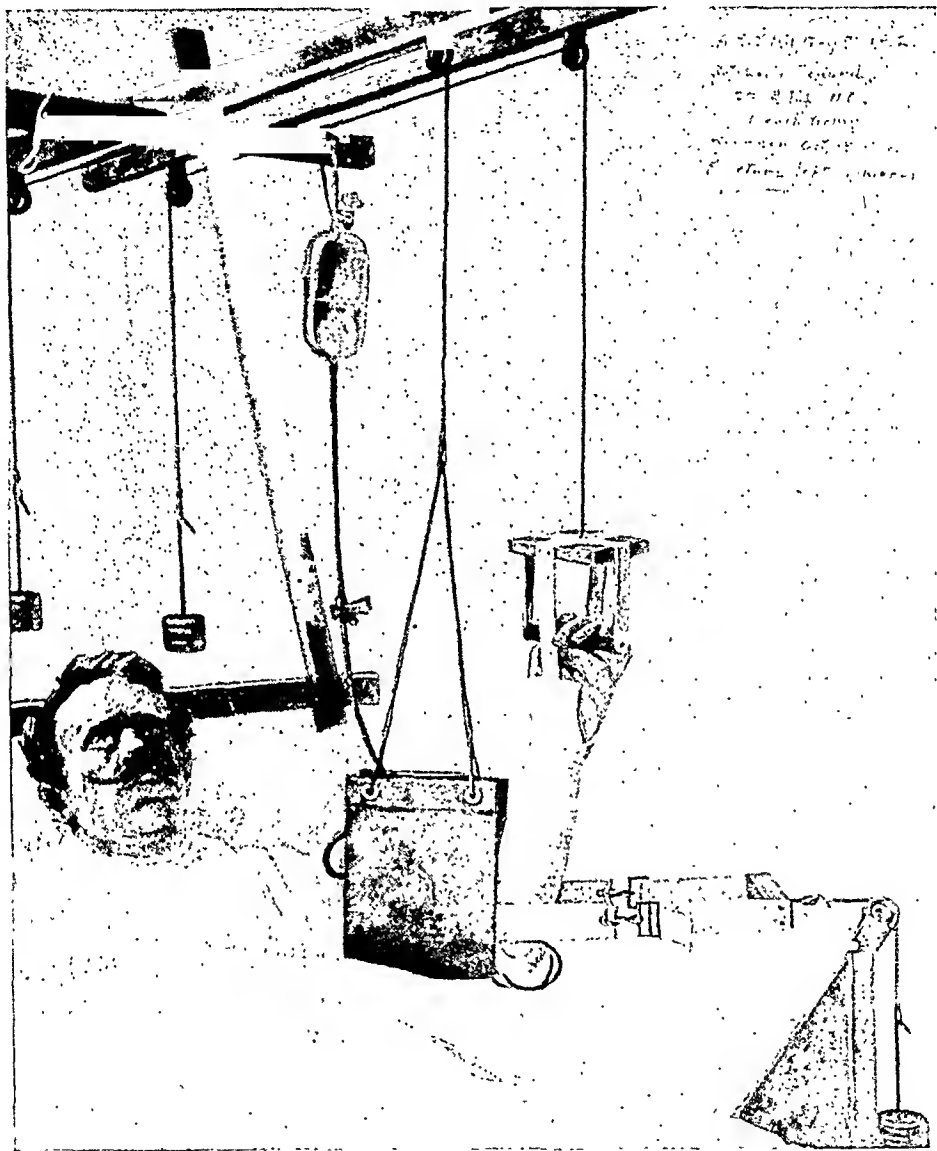


FIG. 1.—Compound fracture of humerus suspended in abduction. (Photograph of colored drawing made by Sgt. 1st-cl. Owens, M.D.)

The arm is supported in a sling from an overhead pulley. The forearm is suspended by glued bands in the same manner, but with attachment further away from the body, as its centre is in a plane outside that of the arm, when the member is abducted. Traction is obtained by bands glued to the arm, the wound permitting, more often by a band encircling the arm just above the elbow, and attached by a pulley to the frame, or an abduction

board placed under the mattress. In this way it is always possible to maintain the fragments in alignment by altering the angle of abduction and varying the relative suspension weights on the arm and forearm. In the few cases where abduction and traction alone do not correct a lateral deformity, lateral traction in opposite directions on the two fragments can easily be added.

The disadvantage urged against this method is that it confines the patient to bed. In the case of infected compound fractures of the humerus, this is desirable. Those who might otherwise be in an ambulant apparatus, we believe are more than compensated by an ultimate shortening of the period of treatment. Especially in the case of soldiers, who are totally useless from the point of view of service, while they are in hospital, the longer confinement to bed has no importance whatsoever and in fact is indicated, provided they can be thereby fitted more quickly for duty.

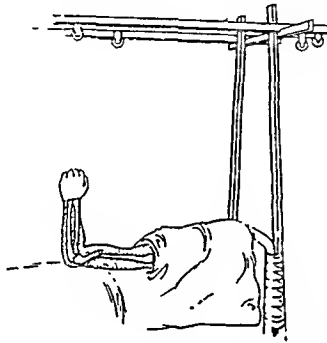


FIG. 2.—Fractured arm as admitted. (Figs. 2-4 are schematic drawings made from X-ray plates of Sgt. Dustin by Sgt. 1st-cl. Owens, M.D., to demonstrate reduction of a fractured humerus and maintenance in position in the Blake suspension apparatus.)

The advantages of suspension and traction are:

1. Maintenance of favorable position from the point of view of circulation and drainage.
2. Ease and simplicity of dressings.
3. Comfort of the patient.
4. Control and maintenance of reduction.
5. Earlier restoration of function.

With regard to the first three points, it is to be noted that this method was first used in arm cases by Colonel Blake⁴ on account of its advantages in the handling of œdema and infection.

Control of the Fracture.—Is best illustrated by the accompanying photographs of X-ray plates made at the bedside, showing deformities and their correction. A portable X-ray machine is indispensable to the proper treatment (Figs. 2-17).

Earlier restoration of function could only be proved with mathematical precision by a comparative series of cases treated from start to finish under one direction. Those, however, who are experienced in the Blake method of suspension and traction, and who have seen how rapidly patients may regain the use of their arms, are convinced that it allows the minimum of joint

and muscle adhesions to form while maintaining a maximum of muscular power and nutrition. While in the apparatus, patients are taught to exercise both elbow and shoulder even before union has begun (Fig. 18). The wrist and hand are always freely movable. Massage is carried on from the start. The patients are kept suspended until union is sufficiently firm to allow them up without support. Once up, we have come to feel that in the ordinary case they should not even be allowed a sling, so that complete mobilization of joints may be carried on as rapidly as possible.

The first treatment of the man with a gunshot fracture of the humerus, after he arrives in hospital, is that of the wound. Almost all shell wounds and some bullet wounds require operative interference. Fragments of bone absolutely detached are removed, but where there is a reasonable prospect of

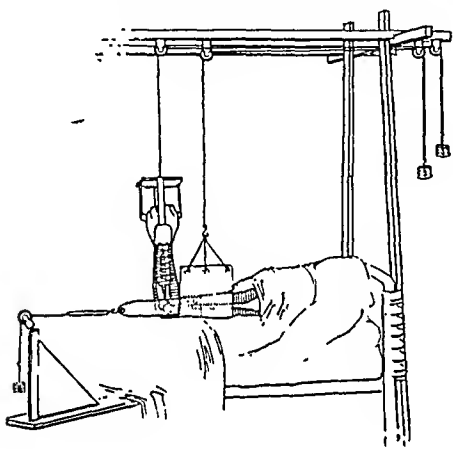


FIG. 3.—Arm has been suspended, position of fragments is improved but there is insufficient traction and too heavy weight on arm.

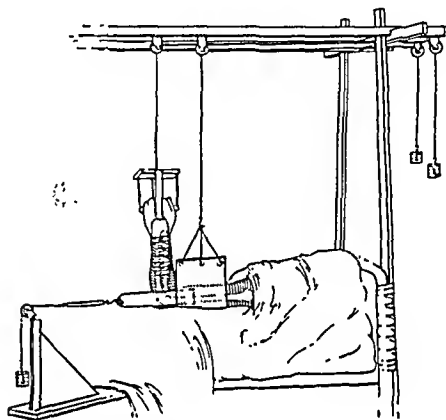


FIG. 4.—Traction has been increased from two to three pounds and the weight on arm reduced from three to two. Weight on forearm in this case was left the same.

viability, they should be left. Delayed union and pseudarthrosis are the sequelæ of injudiciously radical operating.

After the preliminary treatment, the earlier the suspension the better. We believe, however, that it is worth while to apply it to patients received late, provided union has not become firm, and even sometimes with union in the presence of severe or persistent infections.

In the later stages of treatment sequestration should be watched for and sequestra removed as soon as separated, not only because they maintain suppuration⁵ and inhibit union, but because of their liability to become enclosed in cavities of new bone with outlets too narrow to permit of their extrusion. Should this so-called "dice box" condition arise, a free laying open of the cavity with consequent weakening of the bone is necessary to effect a cure.

The number of cases in the records of the hospital, on which this study is based, is 152, of which 105 were Americans and 47 French. Of these, 26 were under observation for so short a time that they add little to the series, and in a number of other cases the records are so scant that their value is not great.

Missile.—The question of missile has considerable importance because of the greater liability to infection of shell wounds. Many bullet wounds can be treated as simple fractures. It is well known that they often unite more rapidly than the ordinary simple fracture, because of the greater stimulation to repair that such comminuted fractures receive, as opposed to the transverse or oblique fracture of civilian life. In this series shell wounds were somewhat more common than bullet wounds.

Wounds were quite evenly divided between the right and left arms.

Type.—The great majority of gunshot fractures are comminuted. The amount of bone injury varies from extensive loss of substance, precluding any hope of union, to trifling wounds of bone (incomplete fractures). In



FIG. 5.—Fracture of upper half of humerus as admitted in Jones traction splint. There is insufficient abduction (X-ray of Pvt. Whitford).



FIG. 6.—Same arm as Fig. 5 after suspension (X-ray of Pvt. Whitford).

between are all gradations of injury and destruction, upon the extent of which depends the outlook as to repair and restoration of function.

Location.—Fractures of the lower end of the humerus united a little more rapidly. Where there is joint involvement, the problem depends primarily on the presence or absence of infection.

Infection.—Infection plays an important part in gunshot fractures of the humerus, contributing almost all of the mortality as seen in hospital; and a considerable share of the morbidity, by prolonging the period of repair and disuse and increasing the amount of scar tissue. It may be divided into two main groups, the early due to the gas-forming organisms, and the late due to pyogenic organisms of which the streptococcus overshadows all others in importance.

The early gas bacillus infections, being infections of muscular tissue, have no direct relation to bone injury, except inasmuch as bone injuries are usually associated with more extensive involvement and laceration of soft parts. Among the 105 Americans of this series, there were seen here seven cases of gas gangrene with one fatality. Among the French there were no cases, explainable undoubtedly by the fact that the latter were not ordinarily received directly from the line.

The streptococcus is largely responsible for the later serious infections and has taken a heavy toll of lives of wounded men. Compound fractures offer ideal soil for it to develop and hang on. On the whole, one is surprised, however, at the comparatively small amount of sepsis in gunshot



FIG. 7.—Soldat Raymond. Compound fracture of surgical neck of humerus. Head is abducted, shaft is not.

wounds of the humerus in comparison with those of the femur. It is due to the smaller size of the bone and the scantier covering of soft parts of the arm. Judicious and careful early operative treatment will avoid many serious streptococcus as well as gas infections, but in the case of the former one is bound to conclude that dressing infections also contribute their share. It seems that the importance of skilful and painstaking aseptic dressings is not sufficiently recognized. There were two fatalities, both Americans, from streptococcus sepsis.

There were five cases of positive streptococcus bacteraemia, again all Americans, four times hæmolyticus, once non-hæmolyticus. Two of those with hæmolyticus infections died. The rest recovered. These five cases represented the severest types of wounds: two had large loss of substance,

and in two there was either shoulder or elbow-joint involvement. Four out of five came to amputation.

Other infectious complications were erysipelas (2 cases) and phlebitis (1 case). One moderately septic patient was recorded as having pulmonary infarcts.

Primary and Secondary Suture of Wounds.—The immediate or early conversion of a compound into a simple fracture represents an ideal, the attainment of which would mean tremendous curtailment of infection. Our experience in fractures, however, has led us to be very conservative about attempting these procedures. Only five were made in the whole series. Of these, one secondary suture was entirely successful, and in at least two others, one delayed primary and one secondary suture, there was a gain.



FIG 8 —Same case as Fig 7, suspended in wide abduction.

Secondary hemorrhage occurred three times in American patients. All three were very septic.

Joint Fractures —When a joint cavity is connected with a suppurating compound fracture it offers ideal conditions for sepsis, unless properly drained, including removal of loose bone fragments, because it becomes a bag of pus, continually reinfected from the bone, without proper outlet.

The head of the humerus when hit often suffers tremendous comminution, and the result is that resection, more often than not, offers the only means of drainage. In cases where the fracture only involves the joint by a fissure or fragment, this will not be the case. Uninfected cases not infrequently heal kindly.

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We have had fifteen cases involving the shoulder joint, of which nine came to resection more or less complete. Of the other six, three were wounds of bone; the fourth a fracture of the surgical neck involving the joint but slightly, and the remaining two, uninfected bullet wounds. Resected shoulder cases should be maintained in wide abduction, so that, if union takes place

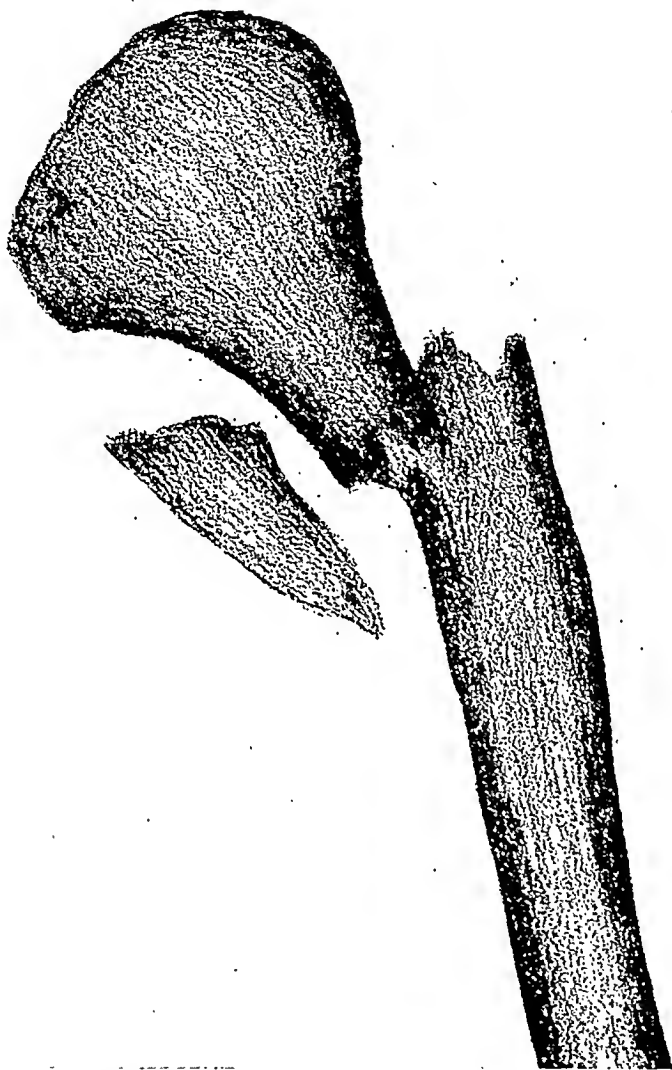


FIG. 9.—Pvt. Rhyne. Drawing from X-ray. Compound fracture of upper third of humerus. Fracture as admitted, showing typical abduction of upper fragment.

between the end of the humerus and the scapula, abduction by means of the shoulder girdle will be possible. As union in these resected cases occurs only after several months, we have, not infrequently, after the wound has quieted down, gotten the patient up in some type of wide abduction splint. However, some of those in our series have been maintained in suspension with advantage until union has set in.

There were seven elbow-joint wounds of which one only was resected. A second who later came to amputation would probably have done better

if resected in the first place. Of the remaining five, two, wounded by bullets, were uninfected.

Union.—The time of beginning union and consolidation is very important from the point of view of comparison of results of different methods of treatment, as well as that of the cure of the patient. There are difficulties, however, in the way of making this determination. In the first place, many

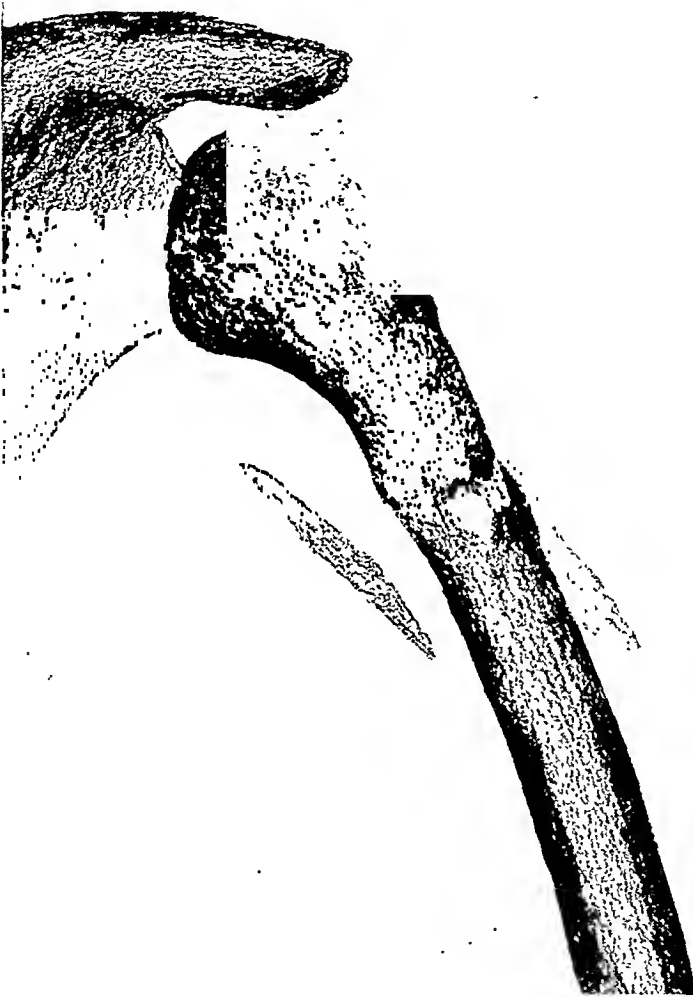


FIG. 10.—Same case as Fig. 9. Drawing from X-ray. Arm in suspension in proper alignment.

gunshot fractures, on account of the extensive bone destruction, whether with or without loss of continuity, cannot unite until after a prolonged process of repair, sometimes not at all. It is manifestly unfair to include such cases in an enquiry as to the average time of union. In the second place, if all observations were made by surgeons experienced in the treatment of fractures and under the circumstances of a steady but not undue supply of cases, the

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data would not only be more complete than was possible under the conditions of war surgery as they have had to be met here, but would undoubtedly show earlier results, as the time of union could be more carefully observed. In compiling the following figures, cases of delayed union, over three months, have been omitted, as well as cases received here six weeks or more after wounding. Other cases have had to be omitted because of the absence of

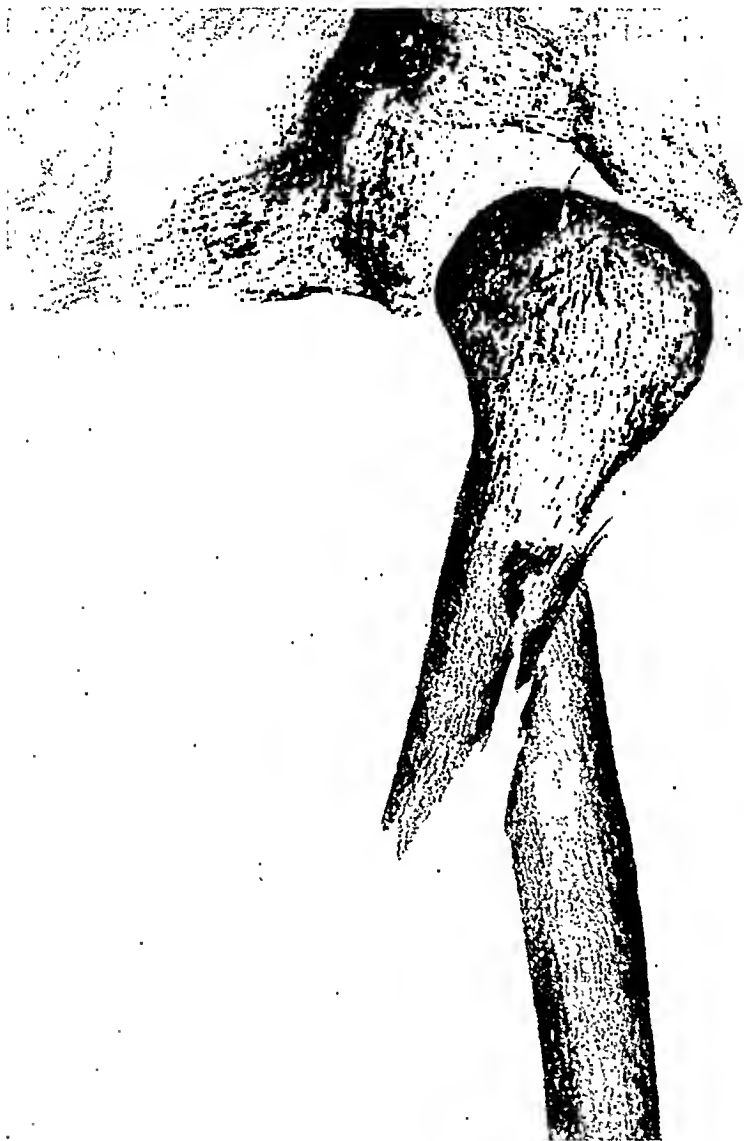


FIG. 11.—Pvt. Hobday. Drawing from X-ray. Arm suspended in much abduction.

notes on their records. It has also seemed wiser to keep separate the American and French figures, because the Americans were received earlier and presented a larger proportion of bullet wounds.

Of the 15 Americans in whose histories it was recorded, the average date of beginning union was 24 days. Of these the three earliest were 15, 17 and 19 days respectively; two-thirds of these were bullet wounds.

Of 11 French cases, beginning union as noted averaged 29 days ; of these less than half were bullet wounds.

More records contained data as to the time of consolidation or firm union. By the former is meant a union so solid that no further supporting appliance is necessary. Whether those notations as to firm union always implied definite consolidation is not clear, but on account of simplicity it is wiser to group the two together. In many instances on account of incompleteness



FIG. 12.—Same case as Fig. 11. Drawing from X-ray. Abduction lessened but not sufficiently.

of records the time of removal from the frame has had to be used as that of consolidation, although patients ordinarily are kept suspended for some days after consolidation is thought to be established.

Of 26 American cases admitted early in the course of treatment, the average date of consolidation or firm union was 40 days. Of these, 8 were 5 weeks or under. It is interesting to note that of these cases the bullet wounds averaged 37 days as opposed to 44 for the shell wounds.

Of 21 French cases the average date was 51 days.

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The earliest case recorded was a Frenchman consolidated on the 23rd day. He had a bullet wound of the lower third of the humerus which remained uninfected and did not require operative interference. This man regained function with great rapidity (see Fig. 19).

Another point of view from which the time of consolidation may be

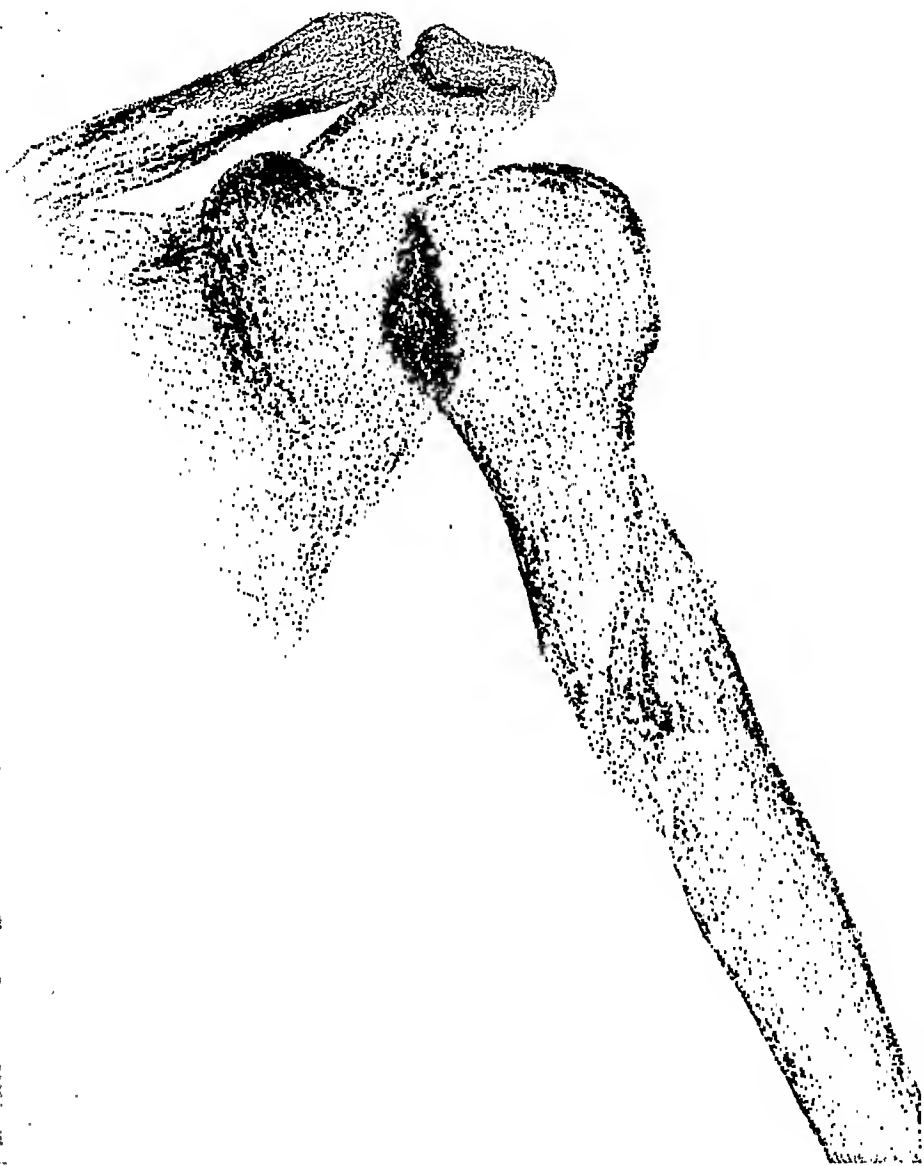


FIG. 13.—Same case as Figs. 11 and 12. Drawing from X-ray. Final position obtained and maintained. See Figs. 31 and 32.

studied is that by periods. Grouping both American and French cases together, the figures are 21st—30th day: 5; 31st—40th day: 17; 41st—50th day: 15; 51st—60th day: 8; third month (61st to 90th day): 5; fourth month: none; after the fourth month, there were 4 cases.

Intimately bound up with the subject of time of consolidation is that of position in which consolidation has taken place; in other words, anatomical

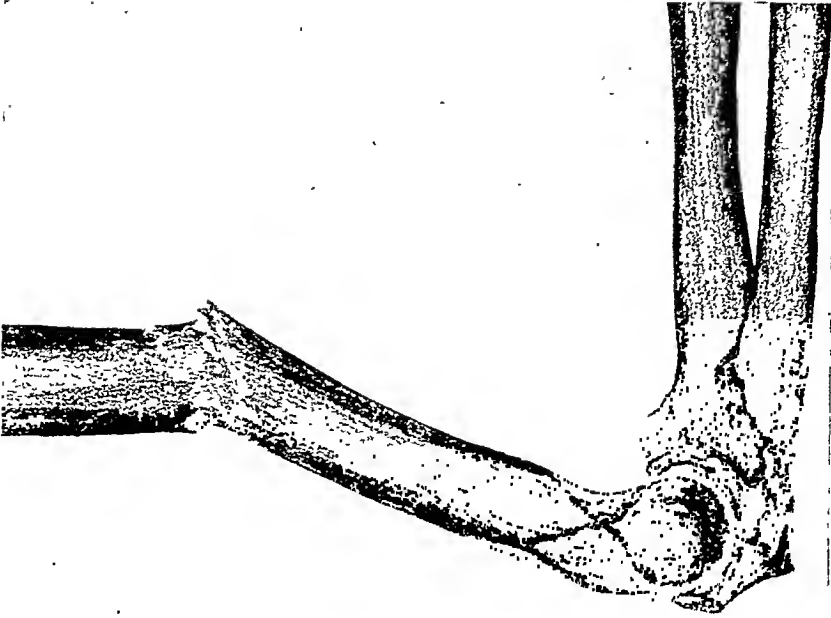


FIG. 14.—Soldat Mignaton. Drawing from X-ray. Simple fracture of humerus. Anterior bowing of arm due to incorrect adjustment of suspension weights.



FIG. 15.—Same as Fig. 14. Drawing from X-ray. Arm after increasing weight on forearm and lessening that on arm.

result. In general the better the anatomical result, the better the functional result.

In this series there was but one case in which consolidation took place in such position that the arm was purposely refractured. With few exceptions, a good anatomical result has been noted, occasionally the final X-ray has shown a slight bowing which is usually hardly apparent clinically. The only convincing demonstrations of results are the X-ray pictures (see Figs. 6, 10, 13, 15, 17, 19-24).

Where a good anatomical result is not obtained by the method of suspension and traction, it must usually be blamed on the surgeon, not the method. As has already been shown, the position of the fragments can be controlled with accuracy. Until union has taken place, however, this position requires repeated checking, clinically and radiographically. This constant watchfulness is a point which an inexperienced surgeon is likely to forget.

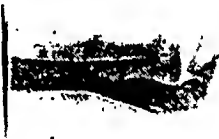


FIG. 16.—Pvt. Gerristead. Compound fracture of lower third of humerus. Showing insufficient weight on the forearm.



FIG. 17.—Same case as Fig. 16. Arm after adjustment of suspension weights. See Fig. 34.

Sequestrectomy.—Seventeen American and 11 French patients came to sequestrectomy, at periods varying from the thirty-eighth to the one hundred and twenty-ninth day for the first intervention. Several of these had to have more than one intervention. This does not represent, especially among the Americans, the proportion of cases which require sequestrectomy, as a considerable percentage were evacuated as soon as union was established. Stereoscopic X-ray pictures give invaluable aid to clinical observation in determining the separation of sequestra (see Figs. 28 and 29). The operative procedure should be done under direct observation which means free incisions. Attempts to separate necrosed ends before there is a line of demarcation usually results in further damaging of living bone, and should not be attempted. On the other hand, separated fragments should be removed at the earliest possible occasion, for reasons already described. It is clear in several of our cases that procrastination has delayed union, and by

prolonging infection and disuse has rendered the problem of restoring function more difficult.

The operation of sequestrectomy is not without risk, first of stirring up a sharp reinfection, which may prove to be a real danger to the patient; and second, of refracturing the bone. The latter cannot always be avoided and is not a grave accident, but causes an unfortunate delay to functional restoration.



FIG. 18.—Pvt. Semfield. F. C. C. left humerus. Superimposed photograph to show mobilization of elbow.

It is not surprising to note that shell wounds were more than three times as numerous as bullet wounds among these cases.

The relation of primary operative interference to late sequestration is a subject in itself, which would require very detailed records to elucidate; these we do not possess, as the majority of the cases did not receive their primary treatment here.

Nerve Injuries.—Nerve injuries occur not infrequently in simple frac-

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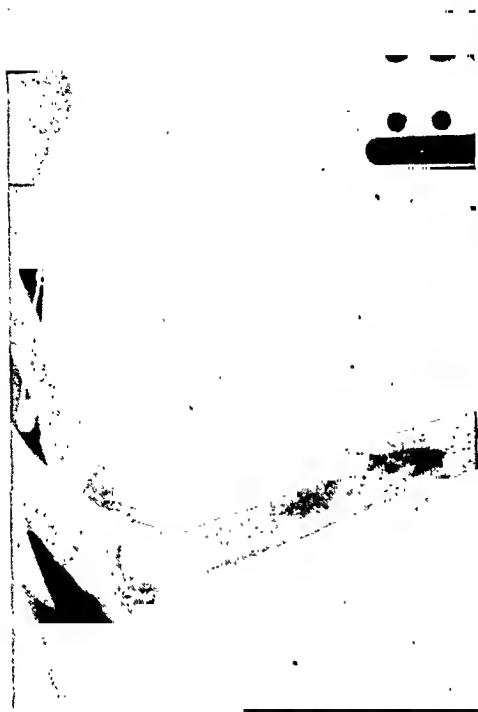


FIG. 19.—Soldat Verdet. F. C. C. humerus. Very rapid consolidation and return of function.



FIG. 20.—Sgt. Baldwin. F. C. C. humerus. Taken about two and one-half months after wounding, when on military police duty in Paris.



FIG. 21.—Pvt. Finazzo. F. C. C. humerus. See Fig. 35.



FIG. 22.—Pvt. Moulton. F. C. C. humerus. See Fig. 36.

tures of the humerus and more often in gunshot fractures. When one considers the numerous large nerve trunks which pass along the arm it is surprising that they escape as often as they do. Our records show a proportion of one nerve injury in every five gunshot fractures of the humerus, among the American patients, and one in three and one-half among the French patients. The musculo-spiral is the sufferer in the great majority of cases. The lesion varies from slight contusion to complete severance of the nerve.

Twenty-nine patients are recorded as having 31 nerve injuries, not all of them complete. They were distributed as follows: musculospiral, 25; ulnar,



FIG. 23.—Pvt. Wayner. F. C. C. surgical neck of humerus



FIG 24.—Pvt. Andrews. F. C. C. humerus.

3; median, 1; musculo-cutaneous, 1; brachial plexus, 1. Of these five cleared up entirely in a few weeks. Six of our French cases with musculo-spiral paralysis were operated on here for the nerve condition, the earliest on the 111th day. In half of these, the trunk was found severed. The cases were not retained long enough to determine the results. The only observation which one may draw from these cases is that the risk of infection is present for a surprisingly long time in old bone wounds.

Refractures.—Among this series there were 6 refractures in 5 cases. The time varied from the fifty-third to the one hundred and fifty-second day; operative interferences (ordinarily sequestrectomies) were the cause four times and falls twice. Union usually takes place very rapidly in these refractures, because callus is already present. In one case, some union was reported one week after the accident. The others, as far as noted, required nineteen, twenty, twenty-three and forty-three days respectively.

In discussing the time of union, one important result of treatment has been considered. Our patients, unfortunately from the point of view of studying end results, have been discharged from here ordinarily before the rapidity and completeness of restoration of function could be determined.

From their progress, however, it has been possible to estimate pretty well in many cases whether they would or would not have any permanent disability. Toward the end of our service also evacuation became infrequent, and we were able to observe a group of cases, then in the hospital, until their function was practically restored. Finally we have seen two or three of our old cases since their return to duty. It is my purpose, therefore, to summarize as far as possible the outcome under the following headings: (1) Deaths; (2) Amputations; (3) Fractures Involving Joints (exclusive of 1 and 2); (4) Fractures of the Shaft (exclusive of 1 and 2):

1. *Deaths*.—In the 105 Americans, there were three deaths, approximately 3 per cent., already mentioned under the heading of infections. One was of gas gangrene on the eleventh day; two of sepsis on the twenty-first and thirty-fifth days respectively. Among the French, for reasons already



FIG. 25.—Pvt. O'Connor. F. C. C. head of humerus and glenoid. Resection of head of humerus. Union between humerus and scapula. Suspended in wide abduction until subsidence of infection and stiffening of shoulder, then gotten up in aeroplane splint. See Figs. 26 and 27.

suggested, there were no grave general infections, although two died of extraneous causes: one man from abscess of the lung from a wound received at the same time as that of his arm, the second from influenza.

2. *Amputations*.—There were 11 amputations among the American patients, of which 2 before admission; this represents 10 per cent. of the series: 5 were done for gas gangrene, 2 others not stated—probably for gas gangrene, and 4 for septic infections. At least 3 of the cases were associated with large loss of bone substance.

Among the French there were no amputations done.

3. *Fractures Involving Joints*.—As already stated, a more or less complete resection is often necessary when the head of the humerus is fractured. The progress of these cases is very slow and they often require repeated sequestrectomies. They are probably destined to a considerable permanent degree of crippling.⁶

Of the nine resected cases three were evacuated with union between the

humerus and the scapula. The average time required for union in these three cases was 130 days. At least one was evacuated with the prospect



FIG. 26.—Same case as Fig. 25. Shows flattening of shoulder and shortening of arm (one hundred and sixty-first day).

of a flail-joint. The remainder were not under observation long enough to judge of the anatomical outcome. The extent of function which the arm will recover in these cases cannot be determined until a much later period (Figs. 25-27).

GUNSHOT FRACTURES OF THE HUMERUS

The one patient on whom elbow-joint resection was done did excellently while here, but the final outcome will remain in doubt for a long period.



FIG. 27.—Same case as Fig. 25. Superimposed photograph to demonstrate mobility, made on one hundred and sixty-first day shortly before evacuation. At this time patient's function was improving steadily but active abduction was still very limited.

Unresected fractures involving shoulder or elbow-joint, whether infected or sterile, are likely to limitation of motion or ankylosis. We have, however, at least one case of shoulder-joint and one case of elbow involvement

who were discharged with a note that motion was good. Both these had remained uninfected and progressed similarly to uncomplicated fractures of the shaft.

4. *Fractures of the Shaft.*—Exclusive of those eventuating in death or amputation fractures of the shaft may be considered under four headings: (a) Cases of non-union; (b) Cases of delayed union; (c) Cases of prompt union in whom restoration of function is retarded; (d) Cases with "uncomplicated" course.

(a) *Non-union.*—Six cases are included in this class, five of whom had marked loss of substance in continuity. These five will probably not unite



FIG. 28.—Pvt. Johnson. F. C. C. right humerus with loss of substance. Admitted the fifty-ninth day, he was discharged the one hundred eighty-ninth day without union. Radiograph shows the loss of substance, a sequestrum at the lower end of the upper fragment (later removed), and a marked absorption of the lower fragment.

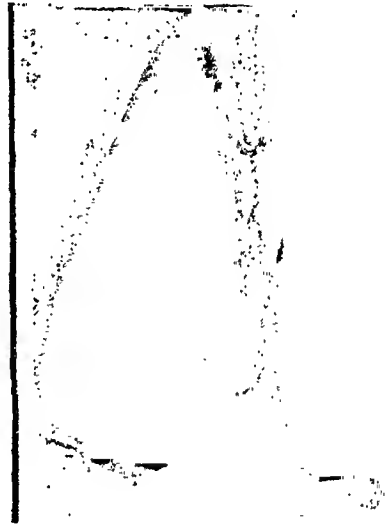


FIG. 29.—Pvt. Keefe. Double compound fracture of left humerus. Lower fracture has united. As can be plainly seen, there is extensive loss of bone from sequestration at site of upper fracture. Sequestra removed eighty-first day. Union delayed on account of loss of bone substance, but will ultimately take place as the gap is bridged by bone-forming tissue.

without operative interference, although, as none of them were under observation longer than one hundred and twenty-five days, this is not certain (Fig. 28). One patient in our series was not recorded as united until the two hundred and twentieth day.

There remains one case who, it would seem, might fall into the class of pseudarthrosis, without loss of substance to explain it. He was operated on the one hundred and third day for non-union, the ends of the bone being freshened. On the one hundred and fiftieth day, he was evacuated still ununited. For those inclined to think that this failure is due to the method of suspension it is only fair to add that the patient was not received for treat-

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ment until the thirtieth day; in other words, after the usual period for beginning union; and that on the fiftieth day he was put in plaster.

(b) *Delayed Union*.—Delayed union in gunshot fractures ordinarily is essentially a matter of bone destruction, depending primarily on the original injury, and secondarily on the subsequent infection. Under this caption are included seven patients. Four were noted as consolidated on the one hundred and twenty-third, one hundred and thirty-seventh, one hundred and fifty-second and two hundred and twenty-third days respectively; three of these had had sequestrectomies. One was evacuated with beginning union, although without consolidation, at the end of three months. He had had an extensive resection of bone fragments at the primary operation.

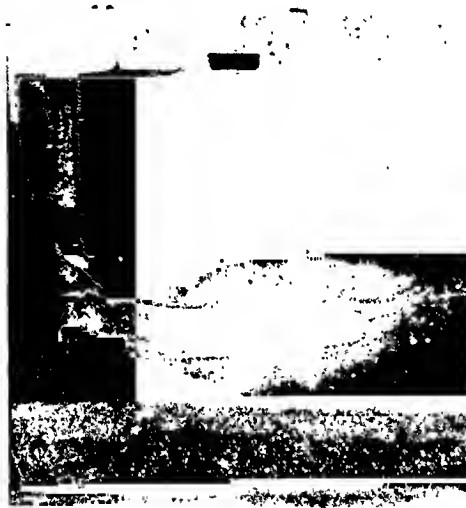


FIG. 30.—Sgt. Yort. F. C. C. right humerus. Considerable degree of comminution. Persistent musculo-spiral paralysis. Union noted as firm on forty-seventh day, at which time a good-sized sequestrum was removed. Arm kept in suspension for some time further on account of infection. Large secondary abscess had to be evacuated. Return of function slow. On account of paralysis outlook for limited usefulness only.

The other two were evacuated on the one hundred and eighth and one hundred and eighteenth days respectively, before union had actually manifested itself (Fig. 29). They are included as cases of delayed union because there was every reason to believe that it would ultimately take place. Both had sufficient bone damage at the original injury to cause, together with the subsequent infection, extensive sequestration. The sequestrectomies in these cases were not done until comparatively late, with the result that the reparation process was undoubtedly retarded. Both, however, have in spite of considerable loss of bone, a continuity of bone-forming elements. Following their sequestrectomies the local condition began to improve.

There remain two other cases who should be classified either as delayed

union or non-union, but were not under observation long enough to determine which. The first was a Frenchman who was evacuated at the end of three



FIG. 31.—Pvt. Hobday. F.C.C. left humerus. See Figs. 11, 12 and 13 for radiographs. Taken eightieth day. Patient was suspended until forty-fifth day.

months without union. His condition suggested a muscle interposition. The other was an American with a transverse fracture. He developed a large terminal sequestrum on each fragment. He was evacuated the one hundred and fifteenth day ununited.

GUNSHOT FRACTURES OF THE HUMERUS

(c) *Cases in Whom Function is Retarded in Spite of Union.*—In cases of delayed union the prolonged treatment of the fracture is a cause of functional disability which in turn requires prolonged treatment and may never be



FIG. 32.—Same as Fig. 31. Superimposed photograph made eightieth day.

wholly overcome. On the other hand, there are certain cases in whom union takes place promptly enough, but in whom function is distressingly delayed. What are the causes?

In the first place, there is often tremendous damage to the musculature of the arm in these gunshot wounds. Function in the muscles involved



FIG 33 — Pvt. Woodville F C C left humerus. Noted as having beginning union twenty-fourth day, firm union forty-fifth, and taken out of frame fifty first. Superimposed photograph made eighty first day.

may be paralyzed for a long period after the injury, and when repair takes place there are scar tissue and adhesions to be overcome. Secondly, in those cases with nerve injury, the partial paralysis reacts unfavorably on restora-

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tion of function in the joints and non-paralyzed muscles. Last, but not least, is infection. We have seen that infection is the all-important cause of hospital



FIG. 34.—Pvt. Gerristead, F. C. C. left humerus. See Figs. 16 and 17 for X-rays. Photograph made eightieth day. Noted as consolidated thirty-fifth day and out of frame forty-second. This patient's return of complete function was not as rapid as many. He is recorded as having had an elbow-joint involvement although the lateral X-ray does not suggest it), which probably accounts for the retardation in his case.

deaths in these cases. It contributes its full share to disabilities. Prolonged sequestration, abscesses, undue scar tissue formation, and more or less chronic disturbance of circulation are all dependent on it. All retard the

use of the arm, and may necessitate its being kept quiet for weeks after the bone is firm. Is suspension and traction to be blamed for any of these cases



FIG. 35.—Pvt. Finazzo. F C C left humerus. See Fig. 21 for X-ray. Noted as having beginning union thirtieth day. Out of frame the forty-sixth day. Photograph the eightieth day.

of delayed union? On the contrary, it offers comfort and postural advantages, which can be obtained in no other way, so that it is often worth while to continue it even after bone union has been established.

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Of our series of cases four whom we had under treatment from an early date after they were wounded, and five admitted between one and two months afterward, illustrate this class of delayed function. Of the four first men-



FIG. 36.—Pvt. Moulton. F.C.C. left humerus. See Fig. 22 for X-ray. Noted as having beginning union thirtieth day, consolidating forty-fifth. Sequestrectomy done forty-sixth day.

tioned, at least two had extensive wounds, three musculospiral paralysis, three prolonged suppuration, two sequestration and one erysipelas (Fig. 30). Of the five admitted between one and two months, four had sequestration and

abscess formation. The function of the shoulder was limited in the fifth by a large scar extending from the arm to the chest.



FIG. 37.—Sgt. Dustin. Simple fracture left arm. Recorded as having beginning union twenty-eighth day. Photograph made forty-fourth day. Note extension bands on forearm. At the time this photograph was made patient had not been released from apparatus on account of tendency to anterior bowing, which had manifested itself a week before, at which time he had been out of bed for parts of two or three days. Discharged to duty (ambulance service) sixty-fifth day.

(d) *Cases with Uncomplicated Course.*—After eliminating the misfortunes and the complicated cases among gunshot humerus fractures, there remain the cases in which repair and restoration progress uninterruptedly.

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They represent the largest class, although the number about to be quoted here is small in comparison with the total, because in the stress of "pushes" patients have had to be evacuated early and rapidly, and historians have often not had the time to record whether union was present or not, much less the extent of functional restoration. This class of cases furnishes the best criterion of a method of treatment, because it allows a judgment to be formed as to the completeness and rapidity of cure ordinarily to be expected.

Twenty-four cases, admitted here shortly after being wounded, have sufficiently full records to be included in this group. Of the eighteen Americans, one-half were evacuated in from 5 to 7 weeks after injury, with comparatively free joint motion, so that it was plain that their cure would be rapidly completed. Of these, two called later at the hospital on assignment to duty as military policemen, some two and a half months after the time of receiving their wound. In one the restoration of function was complete, the other was limited only by a few degrees extension. He had had a temporary musculo-spiral injury (Fig. 20).

Of the other American and French patients, a number who were wounded shortly before the end of hostilities remained at the hospital for a considerable period. The accompanying superimposed photographs best demonstrate their progress in two to three months' treatment.

It is to be said that the photographs were made at a time when it was convenient to get the photographer, and not as soon as the patients could make a good showing. Many of them were able to do as well at a considerably earlier period. Note the preservation of nutrition in the wounded arms (Figs. 31-36).

Before closing, it seems desirable to make reference to three simple fractures which have been treated here by the suspension and traction method. The period required for union averaged about the same as that for our gunshot fractures. As far as can be judged from these three cases, therefore, one need not fear that the lack of comminution in civilian fractures will render them unsuitable for a method which does not immobilize. The accompanying photograph (Fig. 37) of one of them, made before the arm was sufficiently solid to release altogether from the apparatus, shows the possibilities as to maintenance and recovery of function. It seems to those who have worked with this method that its potentialities should make it an important aid in the treatment of simple fractures of the humerus, more especially those that tend to deformity, even though it is admitted that it will often be difficult to confine patients with fractured humerus to bed.

To summarize, suspension and traction in treatment of gunshot fractures of the humerus offers the following advantages: Favorable posture for treatment of the wound; maintenance of reduction for any type of fracture; and early recovery of function. As in the treatment of fractures by any method whatsoever, experience and painstaking supervision on the part of the surgeon are necessary to secure the best results. In a fracture ward, specially trained nurses should be employed. The more experienced one

becomes in the use of suspension and traction in the treatment of fractures the more its possibilities challenge interest and effort, and the better will be the results obtained.

I wish to express thanks to Dr. Joseph A. Blake, under whose inspiring guidance these patients have been treated, and who has kindly given help and encouragement in the preparation of this paper.

The photographs were made by Museum Unit No. 1, Major Robert Ross, whose interest and coöperation greatly facilitated the work.

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FRACTURES OF THE LOWER THIRD OF THE FEMUR*

BY JOSEPH VAN DE VELDE, M.D.

OF LA PANNE, BELGIUM

THIS type of fracture has always been considered one of the most serious on account of its complications. The compounding of these fractures during the war has considerably complicated the treatment. The lower fragment under the action of the gastrocnemii is regularly pulled backwards; any traction on the straight limb will increase this displacement.

We divide open fractures by missiles into three different types. Fractures with: 1. No comminution. 2. Slight comminution. 3. Much comminution.

For each of those types we at La Panne used three different methods of treatment. Those methods are: 1. Wiring. 2. Traction on the femoral condyles by ice-tongs, Steinmann pins, or Willems screws. 3. Depage's vertical suspension of lower fragment combined with horizontal traction on the leg.

The first type of fracture, produced by a bullet at long range or a shrapnel ball or small shell fragment at the end of its flight, has little or no comminution. The soft parts are only slightly lacerated. This is the ideal case for wiring. If, after débridement, we plan to make a primary suture of the wound, we use Depage's wiring method, because the metallic tube that sustains the wire projects out of the wound and affords good drainage. If, on the contrary, we plan to make a secondary suture, we use a Parham or a bronze wire which we remove after a month before suturing the wound. It is understood that wiring only can be used in oblique fractures. In transverse fracture we use the ice-tongs or vertical suspension. In a few cases we have used Lane's plates with good result and without any complication. We do not, however, recommend the introduction of screws in open contaminated fractures. The wiring method seems to us the ideal method for the open fractures of the lower third. It gives a perfect reduction, requires little postoperative attention and permits the suspension in a Thomas or Blake splint.

In the second type we have to deal with slightly comminuted fractures; the soft parts are extensively lacerated, the débridement must be thorough, the fracture carefully explored and all loose fragments of bone have to be removed, but the continuity of the bone is assured by large adherent bone fragments, well supplied with blood. Primary suture of the wound is dangerous; therefore we always plan to make a delayed primary or a secondary suture. Those are the cases in which we use the ice-tongs or Steinmann pins if a low wound does not contra-indicate their employ-

* Read before the American Surgical Association, July 16, 1919.

ment. Willems screws are not to be recommended; they hold badly in the cancellous tissue of the condyle; they loosen under traction, cause pain by pressure on the skin and finally pull out after two to three weeks.

The Steinmann pin seems to us the best method, the knee-joint being bent. Ice-tongs are also good. It is best to place the pin just above the condyle; unfortunately the neighborhood of wounds prevents us very often from doing this; we have then to pass it through the condyles; it is very important that it should be passed in the anterior part of the condyle. Therefore, we have to put it in place under the control of a fluoroscopic screen as was recommended by Fesson. The reason therefor is the following: The condyles rotate on the tibia; they constitute a half circle, the axis being transverse approximately through the centre of each condyle. We could also compare this to a wheel. When the pin is put through the condyles behind the axis and traction is exerted the wheel rolls backwards and thus increases the displacement backward of the lower fragment. On the contrary, if the pin is passed anterior to the axis the wheel will roll forward and the backward displacement on the lower fragment will be corrected. We believe that the pin should not be left in place more than six weeks. The vicinity of an infected wound is a constant danger of infection, so much the more serious because it threatens the knee-joint.

The third type is the much comminuted fracture; the bone is completely destroyed for a distance of one or two inches, the exit wound is large and dirty; the débridement in those cases has to be carried out very carefully and thoroughly on account of the danger of gas bacillus infection. Practically all the bone fragments are detached and have to be removed; there is an important loss of bone substance that might give a non-union, but this may not occur if a bridge of periosteum is present. The treatment here will be very long, lasting several months. For those cases we use the vertical suspension. This is accomplished by passing a bronze wire through all the tissues of the anterior part of the thigh with a Reverdin or a Moor needle. A finger introduced in the wound catches the wire and fixes it securely around the end of the lower fragment. Traction is made by a weight hanging above the bed of the patient, connected by a cord with the end of the wire.

Shortening of the femur is prevented by traction with a Chutro stirrup or Gilliam's method. This suspension can be maintained during months. Some of our fractured femurs were kept for three months with this apparatus and the presence of this wire did not pain them at all nor did it do any harm or cause any complication.

We have also used this method with excellent results in cases of the lower third badly united and complicated by a streptococcic fistula. Here we recommend the subperiosteal resection of the osteitic callus and vertical suspension of the lower fragment. Those cases have done wonderfully.

We may summarize as follows:

1. In oblique fractures with little or no comminution, wiring.

2. In fractures with slight comminution when we expect a beginning of consolidation within the six weeks, ice-tongs or Steinmann pin.

3. In all the cases where one of the aforesaid methods cannot be used and where the consolidation is expected to be delayed a very long time, we use the vertical suspension of the lower fragment, combined with a horizontal traction on the leg.

DISCUSSION

MR. W. HEY GROVES, of England, while largely in accord with Dr. Van de Velde's principles of treatment, believed that the number of fractures with no comminution which required wiring was very small, and that the operation should be limited to those cases in which the widely separated fragments showed a real danger of intervention of the soft parts. Even in those cases the efficient extension apparatus available lessened the need of operation. In the treatment of the second type in Dr. Van de Velde's classification Mr. Groves believed that a pin directly through the lower end of the thigh would inevitably act as a seton, and that in a small definite proportion of cases, in his own experience 3 per cent., sepsis would occur. This danger would be entirely eliminated by tibial transfixion. Since the six weeks, beyond which Dr. Van de Velde said the ice-tongs or Steinmann pins ought not to remain in place, would not see the case through, a measure of the greatest possible value in Mr. Groves' opinion was the transfixion of the tibia and the adjustment of a weight extension.

DR. JOHN B. WALKER, of New York, said that only by the end results in fracture cases would the best means of treatment be determined. In this connection he expressed the hope that a certain amount of public opinion might be conveyed to the office of the Surgeon General, urging that the records of war injuries might be rendered accessible for study.

DR. JOSEPH A. BLAKE, of New York, regarded tibial traction as comparatively safe from the standpoint of infection, because in war injury the wounds extend farther down toward the knee, often interfering with a pin in the femur. In tibial traction, however, there was lost much control of the lower fragments, which was the important factor in the treatment of fractures. In every case where practicable to have the traction upon the femur it should be done.

THE CONTRIBUTION OF THE WAR TO THE SURGERY OF THE KNEE-JOINT*

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OF NEW YORK

THE war having ended, it should be our immediate aim to consider the new surgical chapters written in the great conflict, and to adapt such of them as we may to the surgery of civil life. One hears occasionally that some men returning from abroad have brought back no new thing to civil surgery, but such a barren result must mean a limited experience or a non-receptive mind. Among the many important contributions may be mentioned: The Principles of Débridement in Wounds; The Sterilization of Infected Wounds; The Possibilities of Primary and Secondary Suture; The Vast Accumulation of Data Upon Fractures and Osteomyelitis; The Large Experience in Nerve-Suture Work; The New Chapter in the Radical Surgery of the Lung; The Demonstration of the Non-Wisdom of the Expectant Treatment of Abdominal Wounds, the First War to Accomplish this Result; and lastly, as important as any other contribution, The Establishment of the New Method of Treatment in Joint Surgery.

The object of this paper is to place concisely before the American surgeon, the real facts concerning the great addition, made by the war, to the surgery of the knee-joint. Willems, the Belgian surgeon, advocated and began to practice in 1915 the treatment which now bears his name. A complete description of this method is scarcely necessary. In September, 1918, the writer published a detailed account of the method, the paper having been written the preceding January, but it was delayed in transmission. It may perhaps be well, however, to briefly summarize the basic principles of Willems' treatment.

Willems' treatment of a wound of the knee-joint may be briefly outlined as follows:

1. Accurate foreign-body localization.
2. Careful débridement of all soiled and devitalized soft tissues and soiled bone.
3. Removal of all loose bone fragments and foreign bodies.
4. Irrigation of the joint with saline.
5. Filling of the joint with ether.
6. *Primary closure of the joint by suture, usually including the skin.* With considerable injury to knee or muscle, it is wiser to close the joint capsule, but leave the skin and muscle unsutured.
7. *Early and frequently repeated active motion of the knee*, no splint being applied, save with massive bone injury. This mobilization is

* Read before the Sharon (Conn.) Hospital Association, July 19, 1919.

begun upon the second day, and is continued at two- or three-hour intervals. The patient is up about the ward, with crutch support, on the fourth day, and is encouraged to walk without any support by the tenth day.

The treatment of infected knee-joints was outlined by Willems in the following manner: Opening of the joint through sutured wounds or by lateral incision, no drains of any kind being introduced. Active mobilization was continued, as with the non-septic knees, the patient being awakened at two-hour intervals, night and day, and encouraged to move the joint. As soon as practicable the man was compelled to get up out of bed, and to use the leg in as normal a manner as possible.

The advantages of this treatment of wounds of the knee-joint were a quicker recovery, a higher percentage of good functional results, and an active soldier back in the line in a few weeks. Many of the cases of septic joints obtained normal functioning knees. Surgeons generally were, however, inclined to be very dubious about such a radical departure. The technic seemed to be in such absolute variance from established surgical principles and practice that some at first concluded that the effort was a sort of fad, and paid little heed to the new doctrine. Later, when Willems showed in Paris a considerable number of his end results, the truth was evident at once, and the principle of treatment was accepted by most as sound and reasonable.

One may properly inquire what the general opinion has been and is:

A. Abroad, among the surgeons of the A. E. F., at the time of the Armistice.

B. Here, at home, now.

A. In the latter part of November and December, 1918, in company with Major Mixter and Major Kerr, I was privileged to visit all of the evacuation hospitals and mobile units of the American Army, and later, every base hospital in France. The object of this visit was to collect data for a certain report to be made upon the end results in certain special types of cases. Among other classes of patients, results in wounds of the knee-joint were collected and opportunity was afforded to gather information from various surgeons who had operated both in the advanced and base areas. Rarely, one would meet a surgeon who was rather enthusiastic about the results of active mobilization of joint injuries, and he was usually a man who had had service in the advanced zone, and also some work in a base area. In general, however, we had a very definite impression that the surgeons, as a rule, were unenthusiastic and more or less hopeless about this new treatment of joint injuries. They usually stated that they had had few good results as to function of the joint, and that most of the cases had come down to the base sections with infected joints, requiring free incision, and later either resection or more often amputation. Some of the men died of sepsis.

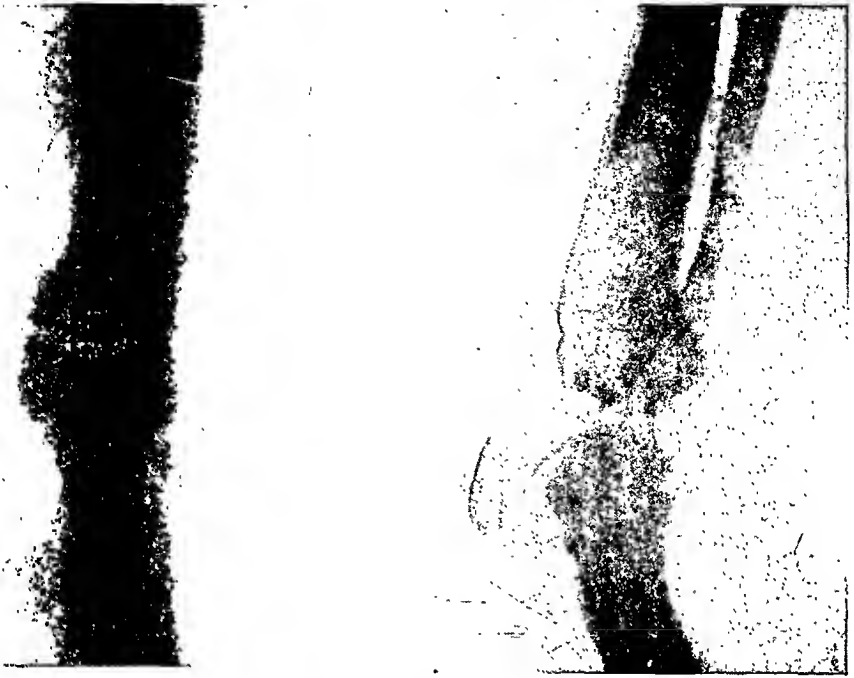
B. Here at home, many men are found who are even now totally ignorant of this new line of procedure, and many who have come from abroad are equally pessimistic about the results obtainable.

What, then, are the reasons for this variation in opinions concerning the soundness of the treatment, held on the one hand by Willems, Delrez, some French, British, and American surgeons, and on the other, by many American surgeons to-day.

A. The Optimistic View.—Those enthusiastic about knee-joint results have invariably seen cases from quiet sectors with fixed lines where the surgery developed has been carefully systematized, and ideal conditions have existed for surgical work. Cases were evacuated from the front line trenches into a well equipped and carefully organized hospital, and most patients were on the operating table within a few hours after injury. Skilled surgical treatment was always available and the efficient after care of every type of case lay in the hands of the man best qualified to handle it. I was very much impressed by the careful, painstaking work of Doctor Delrez at La Panne with the joint cases there. The entire morning was spent on rounds, and each patient with a joint injury was encouraged to move his joint under Doctor Delrez's personal supervision. The operative technic carried out on these cases was finished, a clean dissection being made with the smallest amount of traumatism possible. The work was never hurried, and when the operation upon the joint was finished, one had the conviction that a careful débridement of all soiled tissues had been accomplished.

In the considerable number of knee-joint injuries in Doctor Delrez's service, the results were really excellent. Even in the cases in which infection occurred, active mobilization of the joint was continued without ceasing. Upon morning rounds, the patients with infected knee-joints who had not been following out the principle of active mobilization could readily be picked out without even questioning the man, as the higher temperature and the man's complaint of pain testified at once that the joint had not been moved. In other words, the only efficient drainage of a septic knee-joint that is possible is the movement of the joint itself. Dressings applied should not be confining, that they may interfere as little as possible with joint movements. It is indeed a weird experience to see a man walking about a hospital ward with a considerable opening over the knee-joint, through which one may look directly into the joint cavity, and from which is exuding thin, purulent material, and yet see this man bend his knee and extend it to the normal ranges without any pain and walk about with perfect comfort.

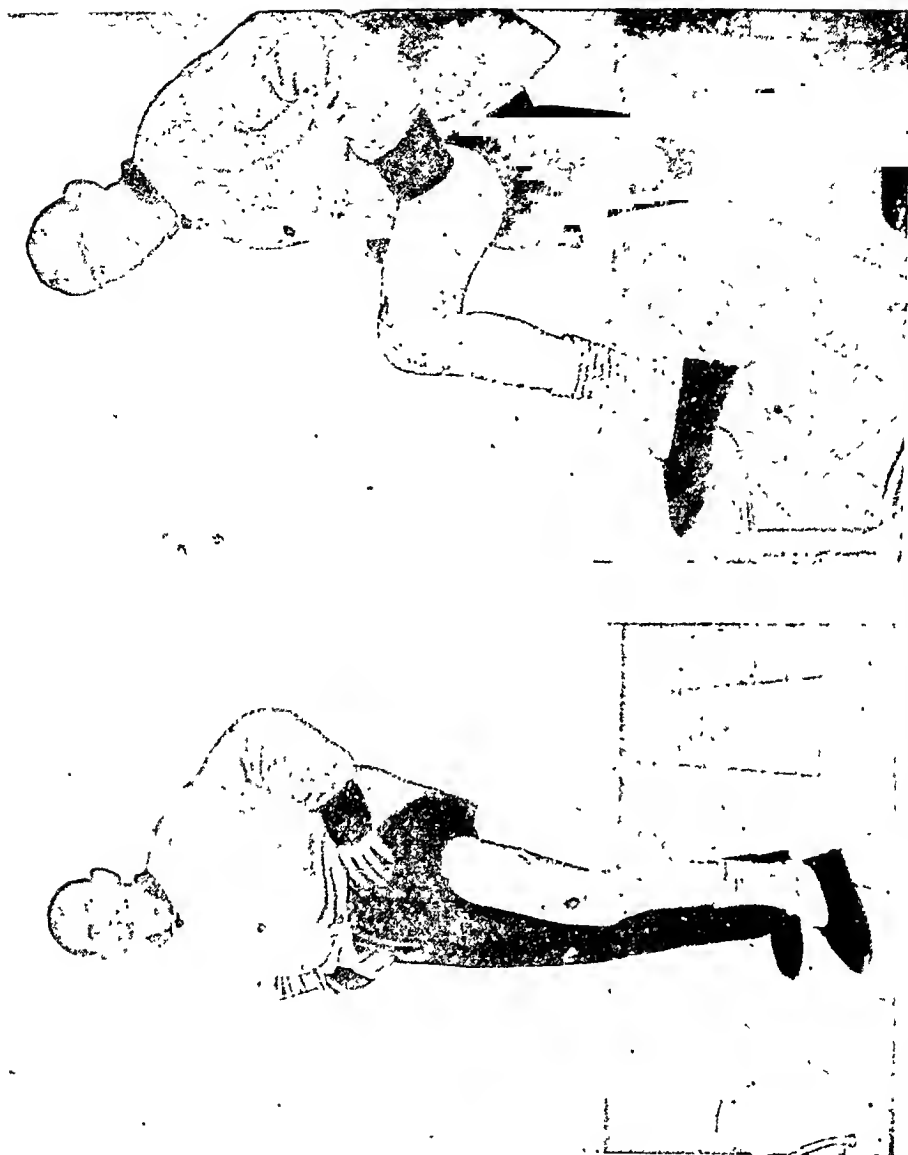
B. The Pessimistic View.—In contrast with these ideal conditions on certain sectors of the front, the problems confronting the medical corps of the United States Army were most of the time difficult and very complicated, due to the activity of the campaign and the evacuation necessities of the wounded. A further analysis of the reasons for some of the



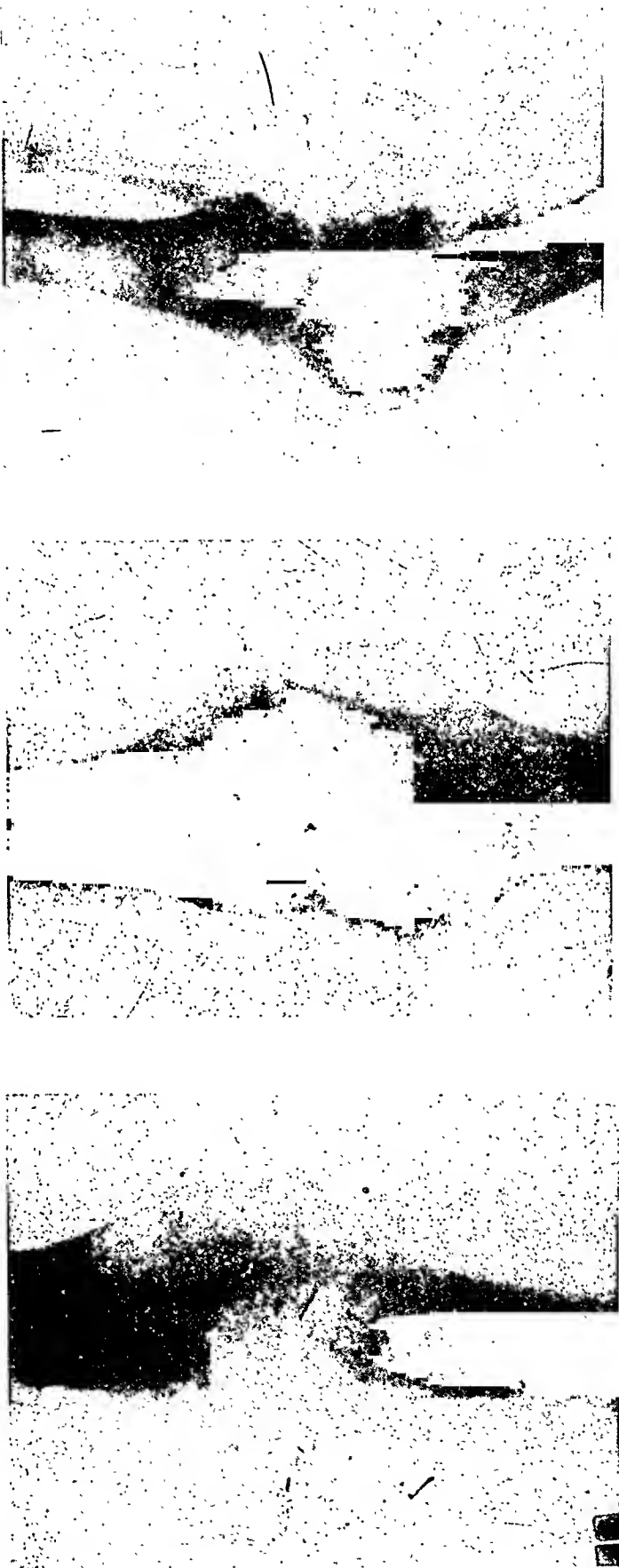
FIGS. 1 AND 2.—Penetrating bullet wound of right knee-joint.



FIGS. 3 AND 4.—A. Hoyois. Service of Dr. Delrez of La Panne. Penetrating bullet wound of right knee-joint. 1. Open operation. Primary closure. Immediate mobilization. Picture taken three and a half weeks after operation. Joint function normal.



FIGS. 5 AND 6.—G. Neuteleers. Service of Dr. Delrez of La Panne. Penetrating shell wound of left knee-joint. Suppuration after operation. No pain. Large return of function. Normal use of joint although anterior opening into joint still persists.



FIGS. 7, 8 AND 9.—Penetrating shell wound of right knee-joint with marked splintering of patella and internal condyle. Patella and part of condyle removed. Suppurated.

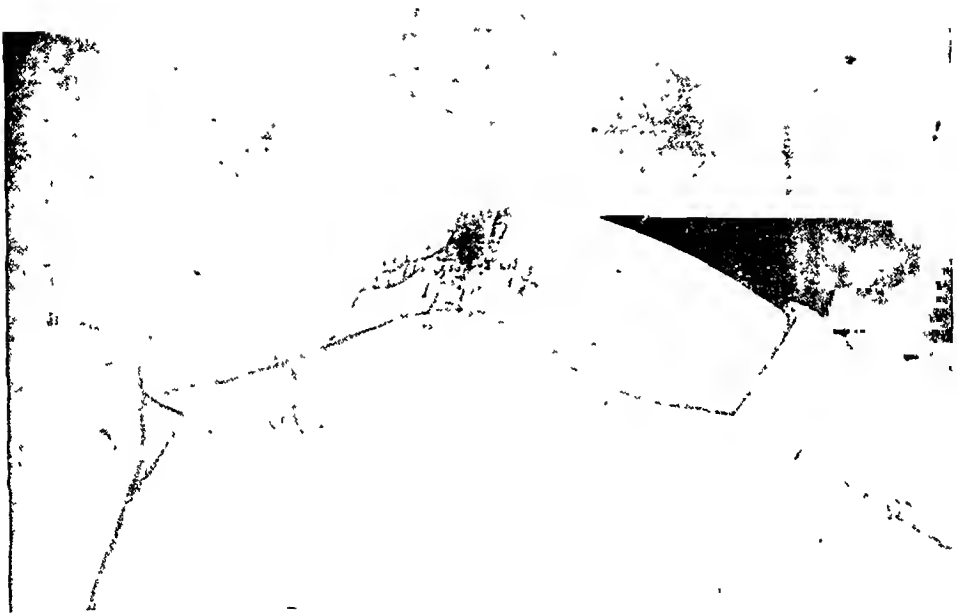


FIG. 10.—Shell wound of right knee-joint, posterior view of case shown in Figs. 7, 8 and 9.



FIG. 11.—Shell wound of right knee-joint showing method of support and dressing case shown in Figs. 7, 8 and 9, four weeks after operation. Flexion of joint. Extension by pulleys. Later plastic operation on extensor tendon gave useful joint with brace.

poor results in knee-joint surgery revealed the fact that the case had passed through several hands up to the time that it had reached the base area. Although the man in the advanced hospital may have started the treatment along perfectly proper lines, the active mobilization was frequently discontinued during a trip down in the train or in the hospital farther to the rear, and the whole early treatment was vitiated. It is almost impossible to get a knee-joint back on active mobilization if the man has been allowed to keep the knee immobile during a period of several days. In some instances, a surgeon in an advanced hospital may have done a careless débridement of the joint, and any type of treatment following such a procedure would necessarily be ineffective. In times of great push, evacuation was so difficult through roads packed and jammed with supplies, guns, ammunition, troops and ambulances, that wounded men could not reach their first hospital for operation in from fifteen to twenty or thirty hours. Under such conditions, the ultimate results of knee-joint injuries would necessarily be less favorable. The marked exception to the conditions present along the American front was the situation at American Evacuation Hospital No. 1, near Toul, serving most of the time a fairly quiet sector of the line. Picked surgical talent was assigned to carry on the clinical work here and the whole setting for ideal surgery was complete. Although no accurate figures are yet at hand telling the end results of any particular group of cases, I believe one can say without exaggeration that the surgical work done upon joints in this institution will compare favorably with that of the best surgery of the other armies, and that the end results in the joint cases treated here were excellent.

Conclusions.—American surgeons will, therefore, not attempt to carry over into civil practice the technic and type of treatment which we have outlined as present under conditions of push in the American Army abroad. The best surgical judgment will rather seek out some institution or institutions where a quiet line and a well-organized stable hospital, furnishing the best of surgery under ideal conditions, gives the nearest approach to civil practice. We may have absolute assurance that the same results may be obtained at home as these picked hospitals furnished, and we may confidently believe that the treatment proposed by Willems and practiced by himself, Delrez, and many others, is sound and here to stay, and represents one of the outstanding contributions which the war has brought to civil surgery.

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POCKETING OPERATIONS AND OTHER SKIN AND FAT TRANSFERS.*

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THE so-called pocketing operation of Italian origin, and other plastics, whereby skin and fat are transferred from one portion of the body to another, are of very great value in the elimination of deforming scar tissue and in the conservation of important structures. Several portions of the body are covered by freely mobile elastic skin underlaid with a plentiful layer of fat. By making use of some of the plastic procedures described in this article, it is possible to take skin and subcutaneous fat from areas where it can be spared and transfer it to localities where it is very badly needed. Managed with a reasonable degree of judgment and skill, the method is practically certain of success.

Grafts in the course of time usually take on the appearance of the skin of the region in which the implant is placed. For instance, a transplant from the upper arm to the nose loses its hairs and takes on a characteristic oily appearance. Transferred flaps, while at first anæsthetic, eventually regain the sense of touch through the projection of sensory nerve fibres from the surrounding tissues. The confinement of the operated part in a comparatively fixed position is tedious but not painful. Some of the indications for the transfer of skin and subcutaneous fat are: For the purpose of filling deep depressions caused by the loss of portions of the bony and soft structures of the body. The restoration of the soft parts preliminary to certain operative procedures on bone and tendon. For the purpose of replacing large deforming scars of low vitality (Figs. 1 and 2). To cover raw surfaces left by the excision of granulating areas, or by the débridement of bone sinuses. To round out and put in proper condition for weight-bearing, painful and unhealed stumps. To cover recently denuded bone, such as the fingers after severe lacerating and crushing injuries. The technic is simple but must be exact. Flaps for the face, neck and nose are usually taken from the upper arm. For the eyelids the thin skin from between the fingers is well suited. For the hand, fingers, forearm and wrist, transfers are made preferably in most cases from the abdominal wall, but also from the chest, back, gluteal region, outside, front or inner side of thigh, and from the opposite arm. For the feet and legs transplants are taken from the calf or thigh of the

* Authority to publish granted by the Surgeon General, U. S. A., July 17, 1919.

opposite side. The posterior surface of the thigh is a suitable place from which to take a flap for the leg of the opposite side.

The flaps are cut either single- or double-ended, as the exigencies of the case may demand. They are cut about one-third larger than the actual measurements would seem to call for, so as to allow for shrinkage and to avoid tension. The flaps are cut with a generous layer of underlying fat which carries a good blood supply as well as giving a full measure of protection to tendons, nerves or other important structures lying underneath. If a sufficient thickness of fat is used to make the implant rise above the level of the surrounding tissues, the excess of fat will ultimately be absorbed, as nature's constant effort is to restore the natural contour of the body. During the process of healing in place, all skin transplants thicken slightly, but the excess of tissue disappears with use and time.

Hæmostasis must be thorough. The bleeding point only is caught with light forceps. Double zero plain catgut is used for the ligatures. The statement sometimes made that ligations about such flaps will cause sinus formation is obviously based on theory rather than fact, as in our series of cases, we have made free use of ligatures whenever indicated. The suture of the skin edges of the transplant to those of its bed must be done with care and accuracy. The sutures should be inserted very near the skin edges and should be tied with the minimum amount of tension.

When a comparatively narrow bridge of skin has been taken up from the abdominal wall, the skin edges underneath can be readily approximated without undermining, as the skin at that point is quite elastic. We generally make use of tension sutures of silkworm gut protected on either side with short segments of 4 mm. size rubber tubing.

In some cases the skin edges will have to be undermined and it is at times necessary to cut plastic flaps for the complete covering of the raw surfaces made by raising the transfer flap. In case of a double-ended flap with the arm projected through the opening under the same, the skin surfaces of the arm will tend to come into more or less intimate contact with the chest wall and will interfere with the toilet of the wound of the abdominal wall, making it somewhat difficult to keep the suture line dry and clean. These difficulties can be overcome to a considerable degree by the following expedients: The arm may be slightly separated from contact with the body by the insertion of rolls of gauze at various points, allowing a circulation of air about the wound and avoiding sweating and maceration of tissues. A bridge made of wire, as shown in cut (Fig. 3), is used to accomplish the same result as the rolls of gauze previously mentioned. No gauze or other conventional dressing materials are applied to the operative wounds incident to these plastic procedures. Gauze would only serve by the foreign body reaction to cause irritation and exudation of serum from the raw surface at the base of the flap. The skin surfaces are carefully cleansed with alcohol, ether or Carrel-Dakin solution, several times a day. The wounds are frequently exposed to direct sunlight or to electric light in cold or cloudy weather.

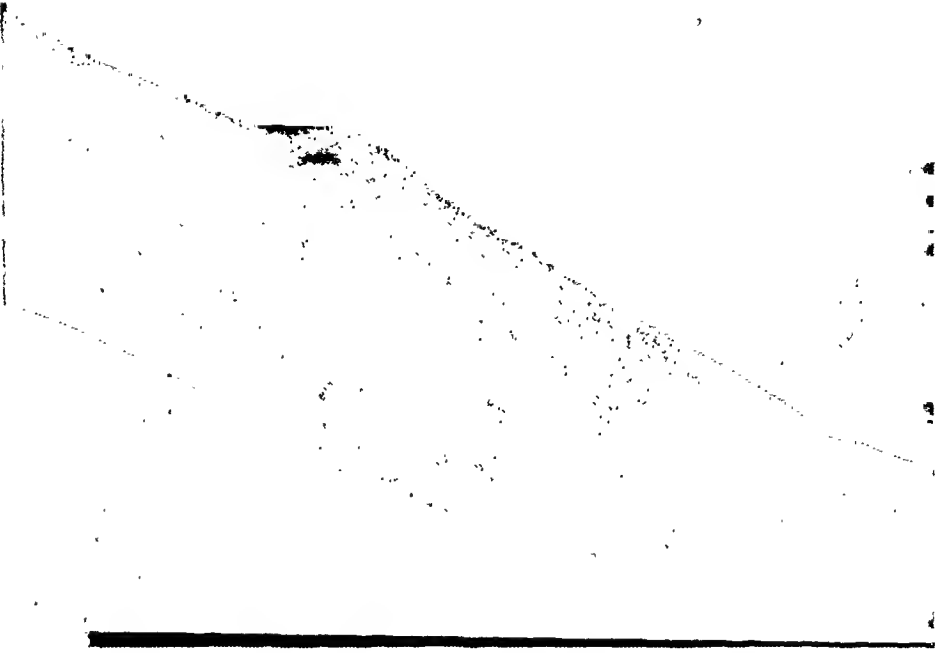


FIG. 1.—Large scar and two sinuses of ulna suitable for operation.



FIG. 2.—Case suitable for bridging operation.

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The length of time required for these flaps to develop a new blood supply sufficient to maintain viability after the ends of the transplants are detached from the body varies considerably for many reasons. Some surgeons have assumed that ten days is a sufficient length of time, others say fifteen days, but personally we have found it better in most cases to wait for about three weeks in order to insure complete success. If the time has been too short there is apt to be some loss of tissue by necrosis at the severed edges. When a double-ended flap has been used, it is often advantageous to detach one end a few days previous to the other in order that the ensuing circulatory disturbances may not be too abruptly brought about.

After both ends of the transplant have been detached they are cut to correct shape, the raw edges slightly undermined and sutured in place. In order to secure primary union it is highly important to excise all granulation tissue about the flap edges previous to suturing. The small raw surface at the base

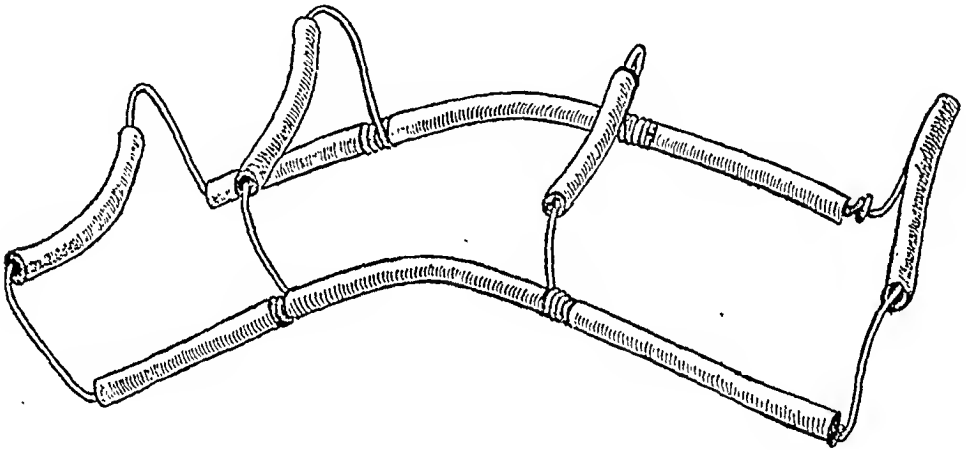


FIG. 3.—Wire support for arm.

of the flap on the body is treated in a similar fashion. The previously described dry treatment with exposure to electric light or sunlight is continued until healing has taken place.

The following case histories are appended:

CASE I.—Pvt. D. High explosive shell wound, middle finger left hand. Ball and tip of middle finger made up of very dense scar tissue firmly adherent to the bone. Tender and painful to touch. Operation: April 1, 1919, the scar tissue on end of finger excised. A small flap from the abdominal wall sutured in place. A silkworm-gut suture was carried through the finger nail in order that a snug fit may be secured. Nineteen days later the finger was freed from the abdominal wall and as the graft looked cyanotic no attempt was made to closely trim or to suture the edges of the graft on the finger. A very small portion of this graft became necrotic. The wound was cleansed with alcohol or ether daily and was exposed to the air, constantly being protected by a small wire cage which was placed about the finger. Epithelial prolifera-

tion was rapid and the transplant conformed to the shape of the finger in a short time (Fig. 4).

CASE II.—Private R. received a gunshot wound through the hand at St. Quentin, France, October 17, 1918. Incident to this injury he lost the second and third fingers along with half of the corresponding metacarpal bones of the left hand. The index and little fingers both being quite stiff and widely separated gave the hand a grotesque appearance and looked more like a pitchfork than a human hand (Fig. 5).

Operation: April 18, 1919, scar tissue excised from back and palm of hand. A bridge flap with two convex projections was elevated from the abdominal wall and sutured into position. Twenty-two days later the abdominal ends of this flap were severed. All granulating areas were excised and skin edges sutured. Ten days later massage was instituted and at the present time the fingers have become quite flexible (Fig. 6).

CASE III.—Private K. A gunshot wound incurred at Bar Sur Meuse, November 12, 1918, through the palm of the left hand had caused a densely adherent scar which completely destroyed the use of the flexor tendons of the thumb and all of the fingers except the fourth (Fig. 7). *Operation:* May 10, 1919, large dense cicatrix excised from palm of hand and a single pedicle flap from the right upper chest wall was sutured in place. The hand was kept from actual contact with the underlying suture line by rolls of gauze, no dressings being applied to any part of the wound. Twenty-one days later the flap was severed and the free ends sutured. Under active massage and other forms of physiotherapy, there has been considerable restoration of function in this previously badly crippled hand.

CASE IV.—Private D. A gunshot wound of left thumb received at St. Mihiel September 15, 1918. Amputation stump with densely adherent painful scar, which was sensitive to the slightest touch, was treated by excision of all scar tissue. An abdominal flap of skin and fat was sutured to the denuded area. Twenty days afterward the thumb was released from the abdomen and the flap ends sutured in the usual way. Unfortunately most of this transplant underwent necrosis. This was probably due to the fact that the denudation was not sufficiently extensive and also because a tight dressing was applied after the patient was sent to the ward. April 30, 1919, the scar tissue was removed and a skin fat flap from the external surface of the thigh was used to make a new thumb stump. There was a slight superficial skin infection following this operation, but the ultimate result was good, and the patient was given a painless stump without the sacrifice of any additional portion of his thumb metacarpal.

CASE V.—Private H. A gunshot wound received in Argonne Wood October 12, 1918, destroyed most of the soft tissues of the right heel and a portion of the os calcis. The result was a discharging sinus and a large area of scar tissue which made locomotion difficult without the use of crutches (Fig. 8). The patient was unable to wear a shoe. The scar area was excised and the bony sinus extirpated. The flap in this case was taken from the calf of the opposite leg. Both knees



FIG. 4.—Case I. After completed operation.

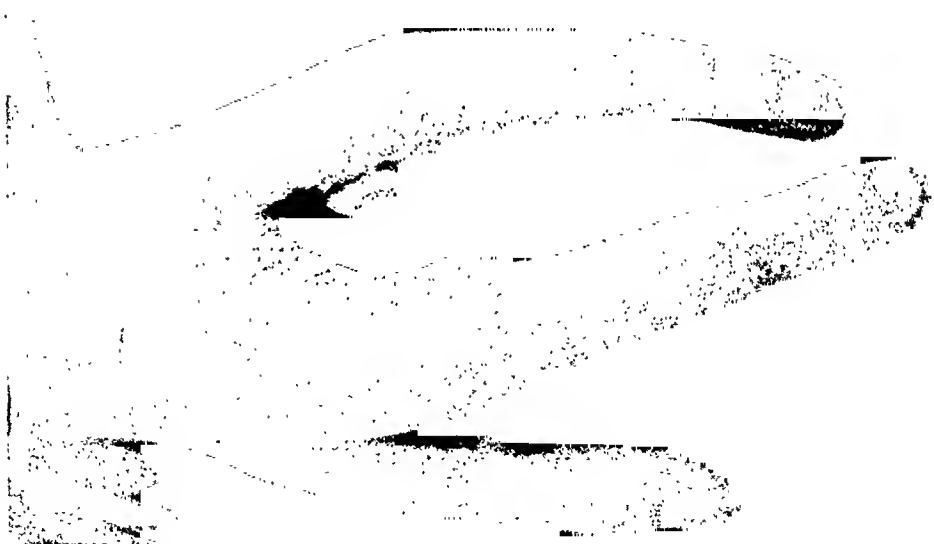


FIG. 5.—Case II. Previous to operation.



FIG. 6.—Case II. When ready for discharge.



FIG. 7.—Scar of hand in Case III.

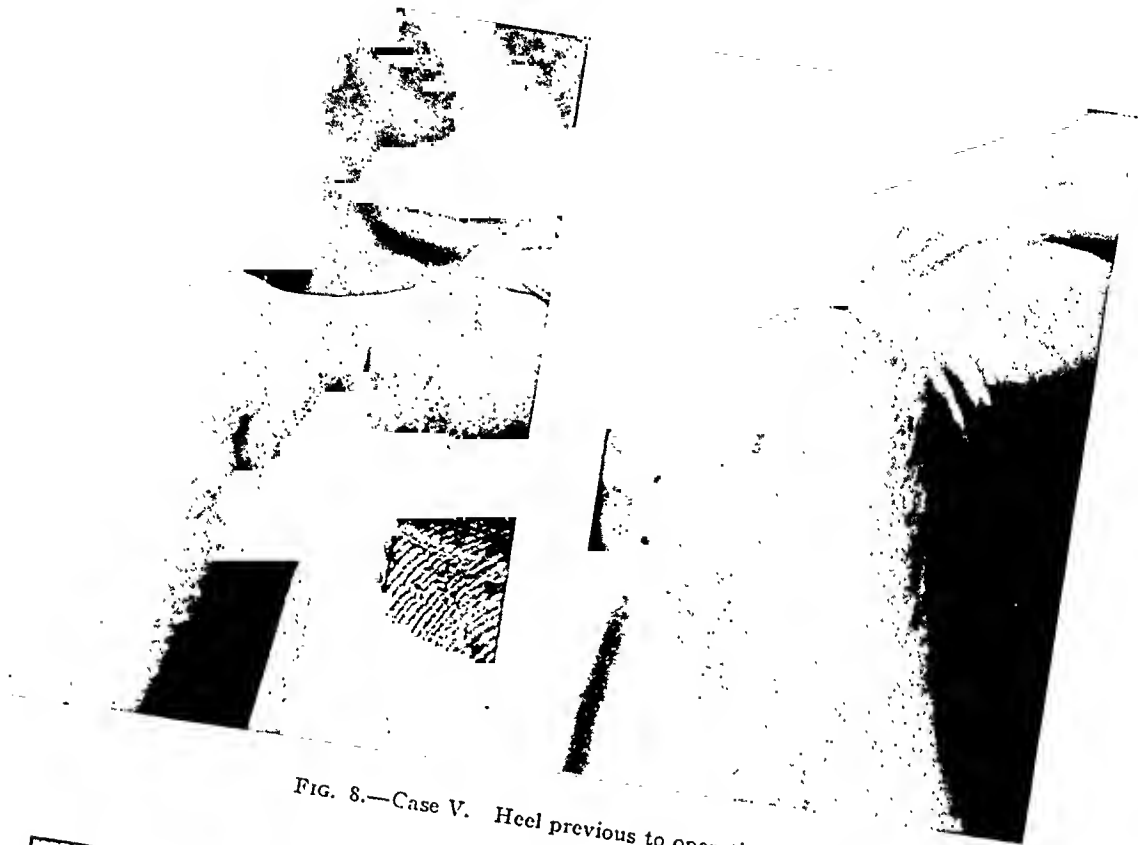


FIG. 8.—Case V. Heel previous to operation.



[FIG. 9.—Case VI. Flap for thumb. Shows mattress sutures.



FIG. 10.—Case VI. After healing.



FIG. 11.—Larger transfer flap, region of elbow.



FIG. 12.—Transplant on arm after healing.

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were fixed with plaster-of-Paris dressing. The distal portion of the injured foot was also firmly secured to the opposite ankle. A few days later the plaster case was removed and the foot was secured from undue movement by a strip of adhesive plaster. Complete healing resulted. The patient has an excellent weight-bearing surface.

CASE VI.—Private S. A gunshot wound between the thumb and index metacarpals of left hand resulting in a dense mass of scar tissue, which rendered the soldier quite unable to abduct the thumb, was excised on May 9, 1919, and a flap of skin and fat from the abdominal wall sutured in its place (Fig. 9). There was primary union. Secondary operation was done twenty days later. By the assistance of massage the range of abduction of the thumb has been almost fully restored (Fig. 10).

CONCLUSIONS

That skin and fat transplants are valuable for the elimination of cicatricial tissues with their coincident deformities (Figs. 11 and 12).

That by their use superficial sinuses in bony and soft tissues can be eliminated and depressions can be filled.

That accuracy of technic is essential to success in this line of work.

That the suture lines must be kept dry. That the absence of dressings and some form of mechanical support that will prevent the skin surfaces of the arm and body from coming in too close contact are valuable aids.

That months of time are saved the patient.

THE BARREL-STAVE SPLINT IN FRACTURE OF THE CLAVICLE*

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I WISH to call attention to what I believe to be a very important contribution to the treatment of fracture of the clavicle, but, at the outset, I desire to disclaim any originality for this splint. In fact, I disavow any credit for it except that of seizing instantly upon a good idea when it was presented to me. The method in question was called to my attention in 1917 by Dr. L. J. Arnold, of Lillington, N. C., who stated that Dr. John A. Bodine, of New York, now deceased, had commended it to his post-graduate classes. In reply to my inquiry Doctor Bodine wrote as follows:

In re the barrel-stave splint for fracture of the collar-bone, all the information that I have about it is that on a trip to Texas many years ago a doctor in Cameron, Texas, showed me the splint on a small boy, and said it was devised by Doctor Spohn, of Corpus Christi. The lad in Cameron was trying to climb a small tree, and to my surprise he had not dislodged the splint and no bad result followed the effort. We have used it in our clinic on a great number of cases and always with entire satisfaction. We have since had a splint modeled in metal with a sliding central joint, so as to make it fit different widths of chests, but, of course, this takes away one of the attractive features—that the old barrel-stave can be quickly found and applied anywhere in the country. It fulfills all the indications, to my mind, with the exception of a tendency of the shoulder to fall downward, so that we have not used it in grown people with heavy muscular or fat shoulders. It has never been written up and never been published, so far as I know, and I think it would be a good thing for you to make it better known.

A letter to Doctor Spohn received no answer.

To apply this barrel-stave splint to a fractured clavicle, the centre of the stave is found, and this should be placed over the centre of the patient's manubrium, at the suprasternal notch. The stave is then sawed off at each end to fit just inside the head of each humerus while the shoulders are drawn backward. One inch from each end a nail is driven into, but not through, the splint. The splint is then padded with cotton, retained by a bandage, and placed in the position as first measured, the concave surface being next to the chest. While the splint is held in place and the shoulders kept firmly back, bandages are tied to the nails, carried under each axilla, and crossed on the back in the figure-of-eight fashion; as many turns are made and the stave is drawn as tightly as necessary. If there is a tendency of the splint to turn or to slip, adhesive plaster may be applied to reinforce the bandage, but it is rarely needed. If the patient is a heavy, muscular subject, the arm is put into a sling.

The appealing quality of this dressing is its comfort. The patient may use his hands and forearms at will without disturbing the fragments, and he is relieved of the distress which the older dressings give. The Velpeau,

* Remarks before the Medical Society of the State of North Carolina, April 15, 1919.



FIG. 1.—Front view—padding purposely omitted from splint.



FIG. 2 —Back view—showing figure-of-eight bandage.

Desault, and Sayre methods are, to say the least, very uncomfortable, while they are, without doubt, difficult to apply and still more difficult to retain. I have treated six personal cases with the barrel-stave; three more have been treated by one of my associates, and several cases by different colleagues. Invariably we have been pleased with the splint and satisfied with the results. One of my cases, a college athlete who did not take the trouble to wear a sling, was injured in December and went back into the pitcher's box in March. A blacksmith from a distant town, who returned home immediately after the first dressing, found that it was slipping. He was not satisfied and, being a good mechanic, went to his shop, fashioned two baby carriage springs, put one in front and the other behind, joining them at each shoulder by a small iron band. The adjustment was perfect and the final result all that could be desired. This suggests that two splints may be used, or that other material will suffice. But the barrel-stave you have with you always.

Undoubtedly the prevailing methods of treating a fractured collar-bone have not given good results, perfect adjustment, or abundant satisfaction to any one of us. Until I came upon the barrel-stave method I had looked in vain for some plan by which a broken collar-bone could be held in place and yet give no discomfort to the patient. I am compelled to say that there has been a disposition to follow teachers and text-books too slavishly, and that certain principles supposed to be vital in the matter do not exist at all. For instance, we have been told that the deformity in fracture of the clavicle is produced "by the action of the powerful muscles attached to the scapula." But you will find that it is due not so much to the pull of the muscles as it is to the dropping downward and inward of the shoulder by its own weight. Dowden,¹ of Edinburgh, has directed especial emphasis against the text-book descriptions of the pulling of groups of muscles as the essential cause of displacement in some fractures. He considers force as the factor in displacement, and criticises unfavorably attempts to put up fractures in special dressings whereby it is hoped to obtain the benefit of muscular pull or to neutralize the effect of muscular action.

This comment applies with singular fitness to fracture of the clavicle. We know that the proper position of the girdle of the upper extremity is obtained by throwing the shoulders backward, and not by elevating them. Indeed, any attempt to elevate the shoulder will result in an exaggerated position, and will actually push the fragments out of line when the clavicle is fractured. Yet in the usual dressings advised for this injury the chief object seems to be elevation of the shoulder. The real problem is to throw the shoulders back and keep them there—a procedure which securely replaces the broken ends. The barrel-stave does this and nothing more.

I ask attention to this simple method of handling a common injury, with the expectation that, unless you have been better pleased than I have with the older, more complicated, and more uncomfortable dressings, you will adopt the use of the barrel-stave splint with much pleasure and satisfaction.

¹ Edinburgh Med. Jour., vol. xxi, No. 6.

PHASES OF WAR SURGERY: BONE TRANSPLANTS FROM THE TIBIA TO THE LOWER JAW FOR LOSS OF SUBSTANCE *

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LIEUTENANT COLONEL M. R. C., U. S. ARMY

It is with much hesitation that the writer presents such a small series of cases. His only excuse must lie in the fact that each case was very carefully studied and followed, and, further, that large series are not yet available. In 1916 and 1917 the writer did 11 of these operations at the American Ambulance Hospital of Paris (militarized July, 1917, as the American R. C. Military Hospital No. 1. A. E. F.). An illustrative case is the following:

CASE I.—B. l'André, twenty-three years; French, 152d Regiment Infantry. Wounded in action August 15, 1915, at Sondemar in Alsace by fragments of high explosive shell. Multiple injuries, including shatter of right portion of lower jaw and compound comminuted fracture of skull in frontal region. Ordinary management, patient passing from one French hospital to another. Hospitalized at Toulouse for one year. Admitted to American Ambulance Hospital of Paris April 11, 1917, with all wounds healed. (Patient has had no symptoms from skull fracture; brain pulsation is felt.)

There was pseudarthrosis of the right side of the body of the lower jaw, with apparently considerable loss of substance. Heavy, dense scar tissue on right side of face in this region. Widest possible preliminary removal of this cicatrix.

July 16, 1917. Bone transplant.¹ (On the preceding day dental splints had been applied by the efficient dental department of the hospital, and "open-bite" supports applied in the usual way.) The entire region of lost bone was a dense mass of hard cicatricial tissue, despite the preliminary attempt at excision of the scar. This cicatricial tissue was removed as much as possible, great care being taken to avoid opening the oral cavity. Posterior fragment exposed, it being much drawn in by the pterygoid muscles. Very careful dissection of the soft parts from the bone, especially at the end of the fragment where it was solidly fibrous and densely adherent. Anterior fragment exposed and cleared. Loss of substance was found to be something over two inches. Seat made in posterior fragment by Albee saw and a chisel, care being taken to go well down into bleeding bone. Seat made in anterior fragment, but this difficult because of dense eburnation of bone. Cultures (proving negative) taken from each cut in bone. Dry wound secured. Fragment of suitable length taken from tibia by twin saw, the periosteum

* Read before the American Surgical Association, June 18, 1919.

¹ The operation here detailed was the type adopted in all of the cases.



FIG. 1.—B-1. Showing transplant nine months after operation.

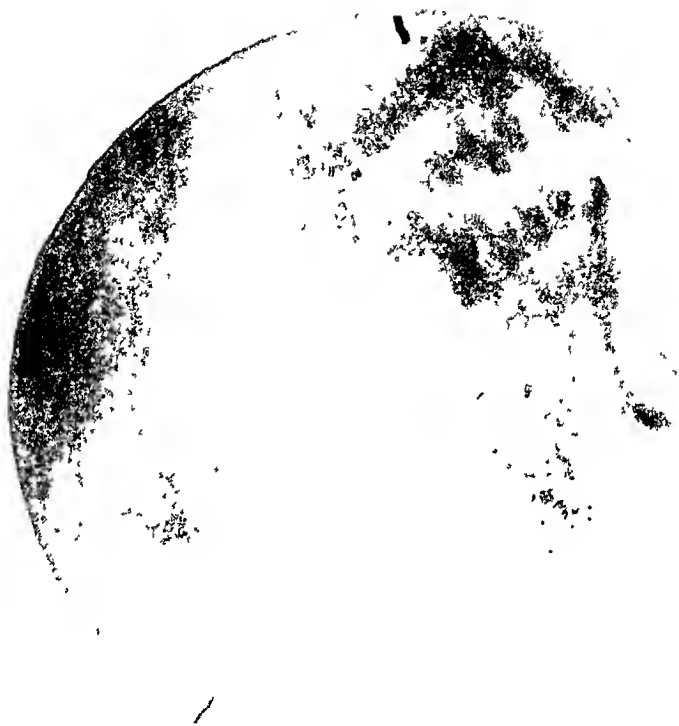


FIG. 2.—B-t. Showing transplant eight months after operation. Black specks represent tiny foreign bodies diffused in soft tissue.

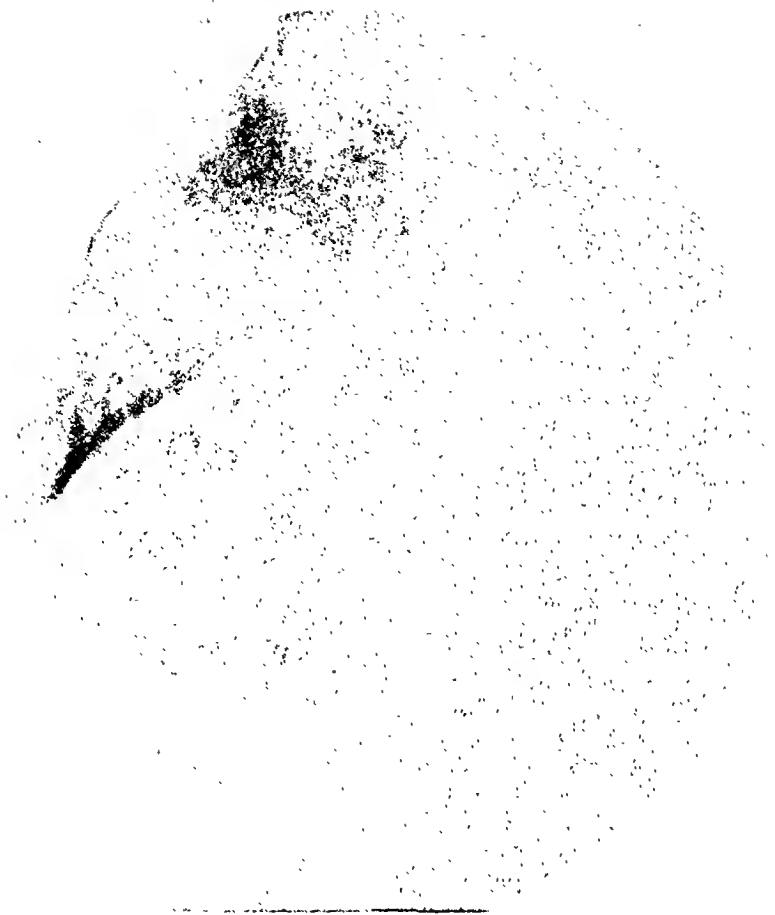


FIG. 3.—Bai-t. Showing transplant eight months after operation.

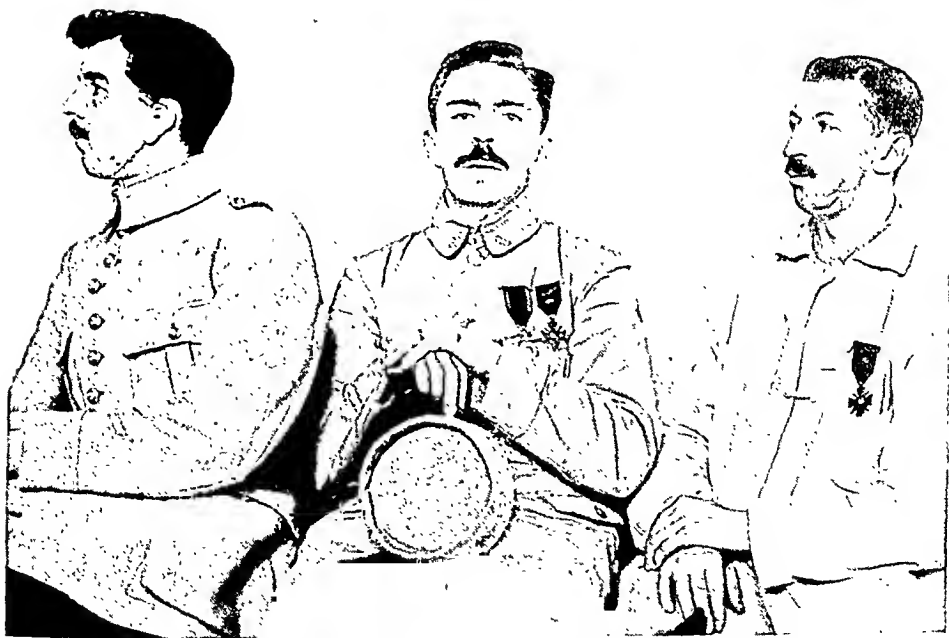


FIG. 4.—Transplants of tibia to lower jaw. Viewed from left to right, the first case was a failure, the other two cases were successful.



FIG 5 —Transplants of tibia to lower jaw. Viewed from left to right, the first four cases were successful, the fifth case a probable success. The soldier in the middle had transplants to both sides of jaw and at time of taking of picture was still in "open bite." (Photograph taken April 3, 1918)

being so raised laterally as to drop over sides of fragment. Ends of graft beveled so that the periosteum dropped over these obliquely cut ends. Transplant applied to lower jaw, held in place by forceps, and the soft tissues carefully sewn over it by interrupted sutures of fine black silk. The sutured soft parts held the fragment in place, but the fragment did not "wedge" into the two portions of the lower jaw proper. Covering of transplant difficult in this case because of the density of cicatricial tissue. Subcuticular stitch to skin without drainage. Very large, firm, carefully applied dressing, with heavy crinoline support. Leg put up in plaster-of-Paris for six weeks.² Each subsequent dressing done with the detail of an aseptic operation. Smooth course. Inter-dental supports and splints removed at the end of three months and solid union found throughout. Patient re-examined from time to time for one year from date of operation.³ The union held. Function of jaw practically perfect. (Fig. 1. X-ray taken nine months after operation.)

CASE II.—Brunet, aged twenty-two years; wounded September 25, 1915. Had been in several French hospitals. Entered the American Ambulance Hospital at Neuilly June 13, 1917, with double pseudarthrosis. Considerable loss of bone on both right and left sides of lower jaw in front of angles. Loose middle fragment very freely movable. Operation on left side November 6, 1917, with "open-bite" inter-dental splint fixation of fragments. No infection. Inter-dental splint not disturbed, and right side subjected to similar operation ten weeks later. Perfectly smooth course. Fixation maintained for six months from date of first operation, when all inter-dental splints were removed and firm consolidation found on both sides of the jaw. On letting the jaws together at the end of six months, no ankylosis was present on either side. In order to get perfect approximation of the dental arcades, it was necessary to extract one posterior right upper molar—a matter of slight surgical importance. This man was kept under observation for eight months after the first operation, or until the American wounded filled the hospital in the summer of 1918. (See Fig. 5. Soldier in middle of picture.)

Results.—Eleven transplants made on ten patients, this last related case being double. In these 11 operations there were three infections, each infected case being followed by loss of the graft. Results in the 11 cases: Seven cases, or 63+ per cent., of complete successes; 3, or 27+ per cent., of complete failures; and 1 case, 9 per cent., undetermined, but a probable success when last seen in June, 1918. (The conditions of success embraced absolutely solid consolidation, excellent dental approximation,⁴ good mastication of not too hard food, and a good speaking voice.)

If, however, we divide these 11 cases into two classes, by years, we find

² The leg gave no trouble in any case.

³ Fig. 5. Second case from left in picture.

⁴ Naturally, suitable artificial teeth were put in.

five operations done in 1916 with 2 complete successes, or 40 per cent., and 3 complete failures, or 60 per cent.; while the six operations done in 1917 (added experience) show 5 full successes, 83 per cent., and 1 undetermined result, but probable success, 17 per cent.

Remarks.—The war has brought greatly increased experience in transplants to the lower jaw, yet there is not unanimity of opinion as to form of operation, or, indeed, as to the real value of any procedure. Leriche (1918, "M. & S. Therapy," 4th vol.) says: "We believe we are justified in concluding that at the present moment the results of bone grafting in mandibular pseudoarthrosis are not demonstrated." As Sébilleau has said, 'they are encouraging, no more.' Morestin told the writer that he used cartilage and inserted it chiefly for its æsthetic value. Imbert and Réal (1917) agree with Sébilleau. Hull, in the second edition of his excellent work, "Surgery in War," 1918, says: "All engaged in this work are unanimous on one point, that it cannot be safely undertaken in less than six months from the date of the injury. As it takes another six months to estimate truly the results, the lack of series of published cases is easily understood." In June, 1918, a surgeon from the British centre at Sidcup told the writer that they were doing some of these cases with the closed-bite under rectal anæsthesia. They had not at that time formulated an opinion as to the value of any particular operation.

It goes without saying that very much time will be needed to determine the ultimate fate of any bone transplants. Further experience will be required to demonstrate the relative value of different procedures, but the writer is convinced that something should be attempted for the relief of these seriously disabled people.

FOREIGN BODIES ARRESTED IN THE DUODENUM

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THE polyphagia of the professional charlatan, the bulimia of the insane, the prehensile and deglutitious characteristics of infants, and the accidental ingestion of foreign bodies by normal adults have been and are from time immemorial a part of the cycle of human events. Surgical literature is voluminous from the earliest times with the history of many and curious examples of the ingestion of foreign bodies; with organs involved in their transit or retention; with the phenomena attendant upon nature's efforts to expel them; and with records of fatal results. From the very triteness of the subject our interest is awakened only when there is retention of the foreign body and the effect "per se" upon the organ involved and the life of the patient.

Of these ingested foreign bodies case reports show the stomach suffers most, ileocæcal next, and finally involvement of the rectum. Considering the anatomical position of duodenum with the duodenojejunal flexure, with its marked angulation, often the seat of partial occlusion, one can but wonder why it so often escapes the lodgement and effects of foreign bodies. Surgical literature teems with reports of gastrotomies, rarely so with duodenotomies. In 1502 the first known gastrotomy was successfully performed by Florian Mathias, of Bradenberg, for the removal of a knife nine inches long, which had lodged in the stomach seven weeks and two days. Patient recovered. The second recorded case by Schwaben in 1635 at Koenigsberg, who by gastrotomy extracted a knife ten inches long. Patient recovered.

Passing to more recent times, Winslow, 1918, in reporting a successful gastrotomy remarks: "The grand total of foreign bodies in her stomach and intestines on admission, as shown by the X-ray and by removal, was 1300, most of them sharp-pointed objects that were liable to perforate the walls of the viscera. This is the largest number of individual objects that has ever been removed from the stomach of the living human being." How many of these sharp bodies passing through the stomach would have found lodgement in duodenum is problematic. That many passed the duodenum is demonstrable in the X-ray picture. Evidently the duodenum seems to be somewhat immune as a reservoir for foreign bodies. This observation is tenable owing to the meagreness of the literature of this subject.

Houston mentions a maniac who swallowed a rusty iron spoon, eleven inches long. Fatal peritonitis ensued and the spoon was found impacted in the last acute turn of duodenum. Perkins reports an open safety-pin swallowed by a fourteen-months-old child. The ray showed the bar of the safety catch passed into the duodenum, while the sharp end was embedded in

the gastric mucous membrane of the pylorus. Operator W. G. Crump, technic not given. Patient recovered. Gerster cites a case reported by Melchoir:

A nurse, aged twenty-four years, was admitted to Kuttner's Clinic, in Breslau. She had swallowed a paper of needles five years before. Ever since then, more or less digestive trouble. For the past fourteen days continuous pain in the right side of the duodenum, with tenderness a finger's breadth to one side of the umbilicus. Antero-posterior X-rays showed four vertically situated needles in the descending part of the duodenum. Abdomen opened through a median incision, but nothing could be felt. Relying entirely upon the X-ray findings, the duodenum was mobilized, now the upper ends of two needles could be felt in the descending part. Longitudinal incision of the duodenum permitted extraction of these. After closure of the intestine, two more needles could be felt close to the pylorus. By pressing upon the duodenal wall the points of these emerged through it and were pulled out. The small puncture wounds were closed over with sutures. Gastro-enterostomy was then established to prevent too much strain upon the duodenal sutures.

Review of the literature revealed that the point of transition between the vertical and third part of the duodenum was the site at which foreign bodies most frequently became lodged. In the hope of stimulating inquiries concerning this subject, I have succeeded in collecting and collaborating the following three cases. These represent the entire number of duodenotomies performed in this district for the past thirty years:

CASE I.—Rudolph G., aged three years, came in June 10, 1918, referred by Dr. R. L. Bidwell, with a history of having swallowed a hairpin three days previously. At that time it was not clear whether the pin was in the stomach or the transverse colon.

Later, X-ray examination by H. W. Dachtler showed the pin to have become fixed in the third portion of duodenum, one end of the sharp point having become bent at an angle and penetrating the mucous coat of duodenum.

Operation.—Duodenotomy, July 12, 1918, operator R. L. Bidwell. Under gas-oxygen anæsthesia, median incision was made. Incision one-half inch in duodenum and pin extracted. Duodenum closed with two layers linen. Recovery uneventful.

CASE II.—Gains A., aged fifteen and one-half months, was referred by Dr. L. A. Brewer on March 26, 1914, with a history of having swallowed a large metal instrument about the size and shape of a sewing machine screw driver one week previously. On March 25th, the day before the examination, the child had begun vomiting, which had alarmed the parents. On X-ray examination by H. W. Dachtler the foreign body was seen lodged in the duodenum with the point upward. It proved to have a sharp point, being known to the trade as a basting thread remover.

Operation.—Duodenotomy March 26, 1914; operator, L. A. Brewer. Under ether anæsthesia right rectus incision was made. The foreign body was readily palpated in third portion of duodenum, the sharp point having penetrated the posterior bowel wall. Having withdrawn



FIG. 1.—(Case I.) "Hair pin" fixed in third portion of duodenum, one end of sharp point having become bent at an angle penetrating the mucous coat of duodenum.

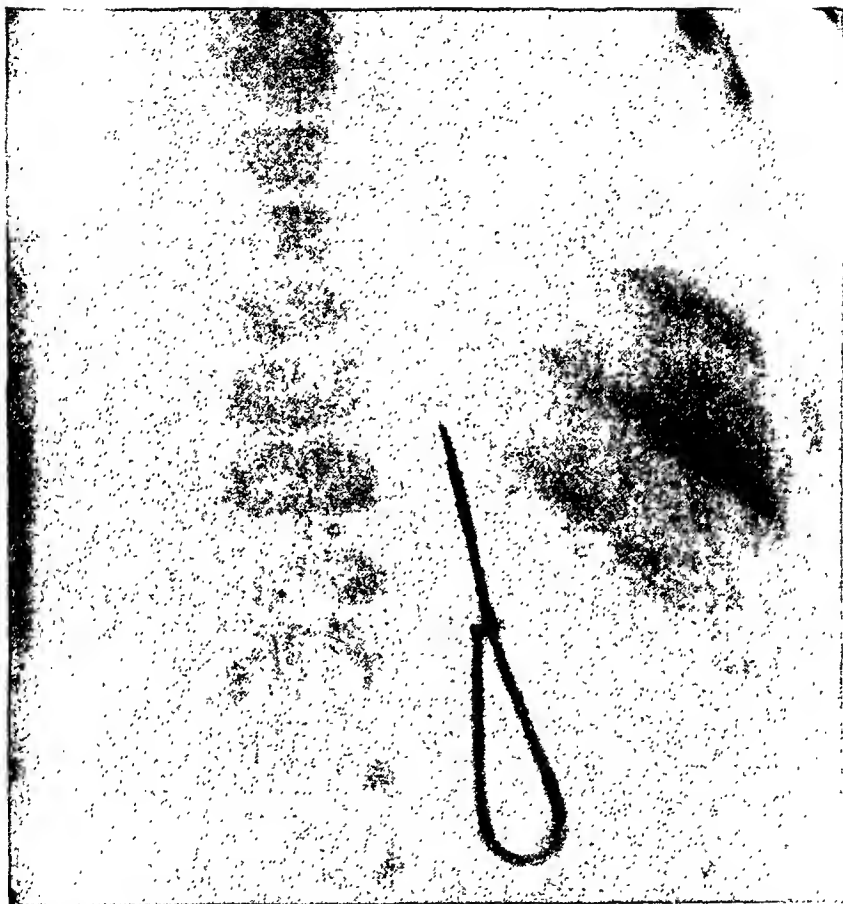


FIG. 2.—(Case II.) “Basting thread remover” fixed in third portion of duodenum, the sharp point having penetrated its posterior wall.



FIG. 3.—(Case III.) “Beauty pin” fixed along the inner edge of the vertical portion of duodenum, the sharp point having penetrated the bowel.

the "basting thread remover" from its attachment, it was pushed through the anterior wall of duodenum, the opening enlarged one inch in the longitudinal axis of the duodenum to allow its extraction. Czerny closure with catgut and running linen Lembert suture. Recovery uneventful.

CASE III.—Florence O., aged thirteen months, first seen September 3, 1918, with a history of having swallowed a "beauty" pin about seven-eighths of an inch long, about two hours previously. On fluoroscopic examination by H. W. Dachtler this was found to be in the stomach. On September 5th another examination showed the pin to be in the second portion of the duodenum in a diagonal position. The child was examined at intervals until September 12, when a small barium meal was given, as at that time the body of the pin was vertical and the pin transverse, and I was of the opinion that the pin had punctured the bowel and that the body of the pin was along the inner edge of the vertical portion of the duodenum. This was definitely proven by the barium meal. Operation was refused at this time and the child was seen on October 8th, on November 6th, and again on November 23rd. At each of these examinations the pin was found in the same location. Operation was then consented to and a last examination was made December 7, 1918, just before operation, to make certain that the pin had not become dislodged.

The plate showed the pin in the position in which it finally came to rest, with the point penetrating the gut completely, so that the body of the pin was in contact with the inside of the duodenum along its median aspect. The pin had attempted to leave the stomach point first in an almost straight position, but the point became engaged with the wall of the duodenum which was too small to allow the hinged portion to pass down and close the pin. It was only as the point penetrated the wall that the body of the pin worked down, due to peristalsis, and it came to rest when the pin was entirely through the gut with the hinge in contact with its inner wall. In this position food passing through the duodenum failed to move it.

Operation.—Duodenotomy, December 10, 1918; operator, Wm. H. Fisher. Under gas anæsthesia, right rectus incision was made. On opening the abdomen the site of pin was readily located, guided by the circumscribed adhesive peritonitis which involved the gall-bladder area. These were separated and the duodenum opened longitudinally one-half inch; pin extracted and the bowel closed with Czerny catgut suture and Lembert running linen. Recovery uneventful, primary union, discharged ninth day.

"ENURESIS" OF ADULTS; HYPERTONIC BLADDER *

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WHEN patients have frequency of urination and nocturnal incontinence since birth, they are usually considered to have a neurosis which will "wear off in time." This diagnosis and prognosis is not correct in most cases. There are three groups of congenital bladder disturbance which should be clearly differentiated. They differ in symptoms, etiology and prognosis.

First.—The continuous dribbling of urine. This form is usually accompanied by obvious organic defects of the genito-urinary organs or spinal cord.

Second.—The persistence of the infantile unconscious reflex. When the bladder has become full urination takes place. The patient is not conscious of a full bladder or of a desire to urinate till after the bladder begins to empty. This condition seldom persists beyond puberty.

Third.—The occurrence of an urgent desire to urinate when the bladder contains only 150 c.c. or less of urine. Involuntary urination takes place if the patient does not void within a few minutes after onset of the desire. This form persists into adult life.

It is with this third group that this paper is concerned. The cases in this group are distinct from the normal incontinence of infants. The condition is known as congenital enuresis but the name is a misnomer. Patients sometimes do not wet the bed or their clothes, though they give a history of having done so in childhood. Considering the data presented below, it is believed a better name would be "congenital hypertonic bladder." I have examined fifty cases in a period of six months at a station where recruits come in at the rate of four hundred a week. It is probable that this number represents less than one-half of the cases, as many are given a medical discharge soon after their arrival. The histories and findings in all of these men are strikingly similar.

CASE I.—G., nineteen years of age. Father is well and strong. Mother has "weak heart" and is "nervous." One brother well. One sister (fourteen years old) has had a similar condition all her life. She usually wets her bed. Patient states he has had "bladder trouble" all his life. No remissions. He gets up three or four times a night. During the day he has marked urgency every 45 to 60 minutes. No burning of urination; very powerful urinary stream.

Three years ago was treated with belladonna for five months. No effect. He has constant pain in the lumbar region, often sufficient to

* This article was written when the author was Director of the Genito-Urinary Subdivision of the U. S. Naval Training Station, Hampton Roads, Va. Permission to publish granted by the Navy Department.

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incapacitate him from all work. He gets tired very easily and is always sleepy. Appetite fair. Feels thirsty very often; drinks seven or eight glasses of water a day.

Physical Examination.—Thyroid slightly enlarged. Tonsils small and buried. Soft systolic murmur at apex. Pulse 80. Knee-jerks and cremasteric reflexes normal. Vertebral column: second lumbar spine cannot be felt. Tenth and twelfth dorsal vertebræ are very prominent. Tenderness over twelfth dorsal and first lumbar vertebræ, most marked over first lumbar vertebra.

The following is a record of the frequency of his urination:

Specimen	Time	Amount	Specific Gravity
1 and 2	9.10	290	1018
3	10.30	110	1005
4	11.10	345	1005
5	11.45	390	1004
12.00, Lunch.			
6	1.15	100	1016
7	1.55	165	1012
8	3.00	250	1006
9	4.20	70	1019
5.00, Supper.			
10	6.50	155	1021
11	8.10	145	1015
12	9.30	160	1007
9.30, to bed—Patient awoke four times. He did not wet the bed.			
13	11.30	180	1007
14	12.30	165	1008
15	3.30	190	1014
16	5.30	145	1015

Cystoscopy.—Bladder holds 480 c.c. Slight trabeculation which becomes more prominent when there is only 300 c.c. in the bladder. Trabeculation confined to the floor and posterior wall. April 10, 1919: Urine pale, alkaline; specific gravity 1.019; slight trace of albumen; sugar negative; microscopic, few epithelial cells. April 14 and 20, 1919, acid and no albumen.

Stool.—No hookworm.

X-ray of Lumbosacral Spine.—All transverse processes, pedicles, laminae and spinous processes are normal.

Summary of Case.—History.—(a) Frequency and urgency; small amount of urine voided each time. (b) Congenital onset. (c) No remissions. (d) Weakness of mother. (e) Similar condition in a sister. (f) Pain in lumbar region. (g) Easy fatigue and drowsiness.

Examination.—(h) Tenderness of lumbar spine. (i) Trabeculated bladder. (j) Bladder capacity tested by injection is 480 c.c.

Examination of the table shows that when the bladder was filling quickly the patient voided relatively large amounts (345 c.c. in 40 minutes and 390 in 35 minutes). This large amount is more nearly the bladder capacity). Usually small amounts are voided.

CASE II.—W., twenty-two years old. Male. Father had similar trouble till he was sixteen years old; otherwise was strong and healthy. Mother died twenty years ago of tuberculosis. No brothers or sisters.

Had trouble with urine all his life. Wet bed every night till twelve to thirteen years of age. Now gets up four or five times a night. During the day he holds urine about two hours; at end of two hours he has sudden urgent desire to urinate. The urine is voided in a forceful and large stream. If he tries to hold his urine involuntary urination takes place in a few minutes. No burning or pain on urination, but a sense of marked relief.

The patient complains of easy fatigue and drowsiness in the afternoon. His appetite is good and there is no unusual thirst. Occasional frontal headaches. Constant pain in the lumbar region made worse on bending forward.

Physical Examination.—No hair on chest. Beard sparse. Pubic hair, female distribution. Thyroid slightly enlarged. Pulse 94. No vertebral tenderness. Cremasteric reflexes and knee-jerks very lively. Long foreskin; left varicocele.

Cystoscopy.—Bladder holds 300 c.c. of urine. Marked trabeculation of whole bladder. Otherwise normal.

Urinalysis.—Color amber. Reaction alkaline. Specific gravity, 1.024; albumen negative; sugar negative.

Microscopic Examination.—Occasional pus cell.

Stool.—No hookworm.

One week after cystoscopy, I filled the bladder with 350 c.c. of boric acid solution. No more would flow in under a pressure of four feet of water. There was a trembling of the lower extremities with marked rigidity of the lower abdomen. The fluid was retained for five minutes. Then the desire to urinate became imperative.

Comment.—This case presents all the symptoms of the first case except tenderness of the vertebral column, and it is the only case in which this tenderness was absent. The reflex spasticity of the muscles of the legs and abdomen from the full bladder is of interest. It was present in four cases. The phenomenon is probably a clue to the pathology of this condition. A partially full bladder sends sufficient stimuli to the hypersensitive lumbosacral cord to cause muscle spasm.

CASE III.—McA., male, white, eighteen years of age. Father died of accident. Mother weak and has "fainting spells." One sister, four years old. Condition of her bladder control unknown. Patient gets up five and six times a night. During the day he has marked urgency every one-half to three-quarters hour. Till four years ago, wet bed every night since infancy. Suprapubic pain from a few minutes before to a few minutes after urination. Appetite good. No unusual thirst. "Short-winded" and gets constant pain in the lower dorsal region more marked on bending over.

Physical Examination.—General appearance that of a Frolich hypopituitary type. Voice high-pitched. Alert and intelligent. Skin smooth,

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cheeks pink. Thyroid slightly enlarged. Cranium small. Tonsils large. Heart and lungs normal. Pulse 104. Extremities rounded and firm, hips broad, breasts developed. Abdomen slightly protuberant, face and body free of hair except for a very few pubic hairs. Pad of pudental fat, penis small; scrotum small, testicles normal. Cremasteric, knee-jerks and light reflexes very lively. Bladder capacity 400 c.c. This amount caused a very urgent desire to urinate. Cystoscopy not done because after meatotomy penile urethra was too narrow for a No. 24 sound. Urine pale, alkaline, albumen negative, sugar negative; specific gravity 1.018.

Microscopic Examination.—Epithelial débris.

Stool.—Positive for hookworm two weeks ago; treated; none present now.

The following is a record of his twenty-four-hour urine excretion:

Number	Time	Amount	Specific Gravity
1	8.50 P.M.	115 c.c.	1.021
2 Awoke	10.25 P.M.	65	1.026
3 Awoke	12.05 A.M.	88	1.021
4 Awoke	1.15 A.M.	86	1.019
5 Awoke	3.10 A.M.	98	1.018
6 Awoke	5.50 A.M.	110	1.018
7 Awoke	6.50 A.M.	170	1.010
8 Awoke	9.55 A.M.	35	1.020
9 Awoke	11.00 A.M.	87	1.024
DINNER.			
10	12.20 P.M.	50	1.022
11	1.15 P.M.	130	1.002
12	1.35 P.M.	45	1.025
13	4.55 P.M.	65	1.126
SUPPER.			
14	5.40 P.M.	110	1.010
15	6.35 P.M.	130	1.010
16	7.05 P.M.	67	1.008

This case of hypopituitarism is presented because it has often seemed that many patients had a more youthful appearance, a higher pitched voice, a scantier development of the hirsutes than other recruits of the same age. These signs were too slight to note in individual cases, but collectively they gave that impression. There is one other case of hypopituitarism in the series. It seems that the study of pituitary function in these cases may yield valuable data.

CASE IV.—McM., nineteen years of age. Father was healthy. Died of an accident. Mother has "heart trouble," is weak and nervous. Three brothers, none of whom have similar condition. He has wet his bed every night all his life. Sleeps soundly. During the day he holds his urine one and a half to two hours, then has marked urgency. Appetite good. Drinks five glasses of water each day. Has constant lumbar pains. Gets tired easily. Feels sleepy in the afternoons. He had a remission a few years ago. For three months he "wet only sometimes,

not every night, but almost every night," and held his urine longer during the day. During this time he was taking "Swamp root and something else." He stopped treatment because it didn't cure him altogether.

Physical Examination.—No important findings except tenderness over the third lumbar vertebra.

Cystoscopy.—Bladder holds 450 c.c. Normal except for fairly well-marked trabeculation on posterior and lateral walls.

Urine amber, alkaline; specific gravity, 1.020; albumen, negative; sugar, negative.

Microscopic examination.—Occasional leucocyte.

Comment.—This man is the only one of the thirty-six who gave a history of a remission, which he believed due to medication; though this man slept soundly all night the drowsiness and easy fatigue were more marked than in most cases. One patient had trained himself by abstaining from fluid after 3 P.M. to sleep without getting up or wetting the bed for six to seven hours; nevertheless, he complained of drowsiness and easy fatigue, as did the others.

CASE V.—D. J., nineteen years of age. Family history, negative. Well till six years ago, when he had epidemic cerebrospinal meningitis. Intraspinal serum treatment. Immediately following he had nocturnal enuresis which has persisted since. Wets the bed every night. During the day he urinates every half hour. He has pain in the suprapubic region immediately before urination. Pain in the lumbar region if he tries to hold his urine. Marked urgency. No history of easy fatigue or drowsiness.

Physical Examination.—Marked tenderness over fourth lumbar vertebra; otherwise negative.

Cystoscopy.—Bladder capacity 350 c.c. Bladder walls markedly trabeculated.

Urine Examination.—Amber, alkaline; specific gravity, 1.021; albumen negative.

Microscopic Examination.—Rare white blood-cells and epithelial cell.

This is the only patient in whom the onset of the disease was in later life. The case is similar to those of congenital origin except for the absence of family history and of the rapid fatigue and drowsiness.

CASE VI.—Age, twenty-five years. Fourteen days in the Navy. Both parents healthy. No similar condition in other members of the family. Was perfectly well before enlistment. Has slept in hammock nine nights. Wet hammock the last five nights. No bladder disturbance during the day. Has some lumbar pain.

Physical Examination.—Negative.

Patient slept on cot two nights, during which he has no enuresis. Then slept in hammock again. Wet hammock several nights for the next two weeks. The three weeks following, no enuresis.

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This case is presented only as a contrast to those included in the above series. Some of these cases of acquired incontinence have frequency during the day and occasionally are more persistent, nevertheless the distinction from the cases in this series is obvious. The onset is recent, the family history is negative, there is no tenderness of the vertebral column and no drowsiness or easy fatigue. When these acquired incontinence cases have diurnal frequency, urgency is absent or slight.

The following is a tabulation of the signs and symptoms in 50 cases:

	Cases	Per cent. of Cases
Symptoms since infancy	49	90
"Weakness" and nervousness in the mother	41	82
Other members of the immediate family have similar conditions (7 cases females)	36	72
Wet bed	30	60
Get up at night (no bed wetting)	16	32
Lumbar pain	47	94
Tenderness of lumbosacral spine	49	98
Drowsiness and easy fatigue	49	98
Frontal headache	25	50
Cystoscopy was done in	26	
Trabeculated bladder found in	23	89

Five cases had X-ray of the lumbosacral spine by Dr. C. C. Hugger. He reported negative findings in all five cases.

Wassermann-Noguchi reaction was done in six cases. All six reported negative by Dr. C. F. Holtegal.

Comment.—All these cases are in males. Several patients give a history of a similar condition in a sister. Considering that the men often do not know of the existence of such a condition in the female members of the family, it is probable that the condition is not uncommon in women.

These cases illustrate a type of bladder disturbance probably due to a congenital hypertonicity of the bladder. The difference between the amount of urine usually voided and the amount of fluid which can be injected, the trabeculated bladder, the powerful urinary stream, indicate increased tonus. The lumbar pain, the tenderness of the vertebral column, the frequency and urgency in the absence of any unusual stimulus, the occasional spasm of the abdominal and leg muscles on filling the bladder, indicate hyper-sensitive as well as hyperactive cord centres.

The cases are characterized by an urgent desire to urinate when the bladder contains from 100 c.c. to 150 c.c. of urine. Involuntary urination takes place if this desire is not acted upon. The physical bladder capacity is only occasionally markedly diminished. The "physiological capacity," that is, the amount the bladder will hold before the bladder contraction reflex takes place, is always less than half the normal. Remissions occur but are rare, of short duration, and not complete.

There is commonly a history of similar condition among other members

of the immediate family. A history of "weakness" and "nervousness" in the mother occurred in 82 per cent. of cases.

Patients are subject to easy fatigue and become drowsy in the late afternoon. With one exception they were mentally normal.

The lumbar pain is often made very severe by any physical work.

Cases present the following physical findings: Tenderness of the lower lumbar and upper sacral vertebræ is almost constant. Occasionally there is evidence of increased tone of the muscle of the lower abdomen.

Cystoscopy gives a fairly constant picture of trabeculated bladder. The trabeculation is found most often posterior to the interureteric ridge and posteriolateral wall; in cases with marked frequency the whole bladder is trabeculated. There was no cystitis. Pelzman independently described this cystoscopic picture, having found it in a series of cases of "enuresis" at Camp Meade. He also noted the constant history of congenital onset and the history of "enuresis" in other members of the family. I believe that is the first description of the condition.

X-rays of the spine and routine urinary examinations were negative.

Treatment.—Many cases give a history of prolonged belladonna treatment without benefit. I have treated three of these cases by daily distention of the bladder with 400 c.c. to 600 c.c. of boric acid solution. One patient reports no improvement after three weeks. Two patients doubled the time during which they could hold the urine and held twice the former amount. The urgency was just as marked as before treatment. Methods of treatment should be investigated. The condition is not merely annoying; these men are unfit for military service and are seriously handicapped in any other occupation.

CONCLUSION

There is a clinical syndrome characterized by occurrence in families, congenital onset, frequent voiding of small amounts of urine with marked urgency, easy fatigue and drowsiness, tenderness to percussion of lower lumbar and upper sacral vertebræ and trabeculated bladder.

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THE ORGANIZATION AND OPERATION OF AN EVACUATION HOSPITAL*

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DURING the war, ideas change from time to time regarding the organization of an evacuation hospital and the function which it should perform. The necessity of treating wounds early and of performing major surgical operations in the advanced zone demanded a larger staff than had been provided in the tables of organization. With the re-introduction of débride-ment into military surgery, the evacuation hospital became the most active and important operating centre in the whole chain of hospitals.

Changes in the physical equipment of the evacuation hospital were necessitated by the changes from trench to mobile warfare. An evacuation hospital must be an actively mobile unit. In order not to embarrass transportation, which is not often available to the extent necessary, such a hospital should be under tentage. The bed capacity should not be greater than 500—425 Gold Medal cots and 75 iron beds for fracture cases. Beds are not needed so much as a force of operating surgeons large enough to take care of the wounded, and a transport system which can provide for rapid evacuation.

The so-called evacuation hospital of trench warfare was not strictly speaking an evacuation hospital, for it was immobile, and in many instances where it could have been moved, the time required in taking it down and setting it up was so great, and the amount of transportation needed to move it so large, that it was for all practical purposes immobile. A hospital which by dint of circumstances is so situated that it receives wounded early but is immobile should be designated as an advanced base rather than as an evacuation hospital.

An evacuation hospital of 500 beds can take care of the wounded of a division providing it has 10 operating teams, and can evacuate the wounded frequently enough to provide beds for those being brought in. A hospital of this type must be easily moved. It should be taken down within twelve hours and be set up and receiving wounded in from 8 to 12 hours after reaching the site selected for it. A water supply must be at hand and transportation provided before such a hospital can function. These are the two prime requirements.

A hospital of this type should be under tentage in order to permit of quick movement and to reduce to a minimum the demands upon the transportation system. Such a hospital is much more compact than a barracks hospital, regardless of how well planned such a hospital may be, and how easily the different parts may be knocked down and put together.

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The operating part of an evacuation hospital such as the one now being described should consist of five Bessonneau, Henri or Dickson tents. There should be 20 ward tents for housing the sick and wounded, one shock tent and one tent for the dressing of lightly wounded. In setting up the tents, the idea of reducing to a minimum the amount of littering and of placing the patients being received so that they are operated upon in the order in which they are received, excepting, of course, those who have been so seriously wounded that immediate care is necessary, should always be kept in mind. What we may designate as a linear set up meets the requirements better than any other arrangement we know of.

Advantage of the Linear Set Up.—In this set up, the receiving tent is placed upon the main road or not far from the same. Directly back of this is placed the second tent, in which bandages are changed, smaller dressings applied to facilitate the location of foreign bodies by X-ray examination, and antitetanic serum administered if none has been given previously.

The third tent is devoted to X-ray work. An evacuation hospital should always be provided with two X-ray machines in order that the operating teams should never be delayed because the wounded have had no X-ray examination.

Directly back of the X-ray tent is the pre-operative tent or ward, provided with litter rests. The wounded on the litters are placed upon these rests in the order in which they enter the hospital, with the exception of the seriously wounded, who are taken care of immediately. Back of the pre-operative ward is the operating tent.¹ The advantage of this set up is that there is a continuous litter from the receiving to the operating tent. It is practically impossible to lose track of the wounded, each being taken care of in the order in which he enters. By this arrangement, there is no possibility of a wounded man being forgotten or disregarded for forty-eight hours or more, for he is always under the observation of litter bearers, who feed the operating room, and besides the cases are checked frequently by the surgical chief or one of his assistants. This arrangement permits the surgical chief to operate and besides enables him to maintain supervision of the pre-operative ward, because of its proximity to the operating tent.

On either side of the receiving ward are placed the shock and dressing tents. The sorting of cases is done in the receiving tent. The lightly wounded, who require dressing only, are passed out of the back of the receiving ward to the dressing tent and the badly shocked are taken directly from the receiving to the shock tent. Littering of shock cases is thus reduced to the minimum.

Two to three tents are reserved as occasion demands for non-evacuable cases. These tents are placed directly back of the operating tent and near

¹ A small room built of wood should be placed at middle of side of the operating tent. All sterilizing should be done in this. No open flame should be allowed in the operating tent proper. A wall tent should be set up at the other end of this room, with which it communicates, in which supplies may be prepared and stored.

PLAN OF U.S.A. EVACUATION HOSPITAL 5 — VILLERS-COTTERETS

SKETCHED BY MICHAEL J. JAMES
K.L.D. 10

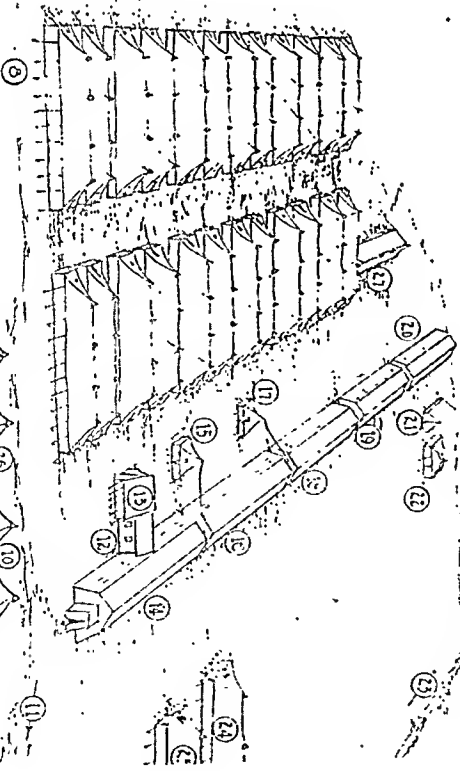
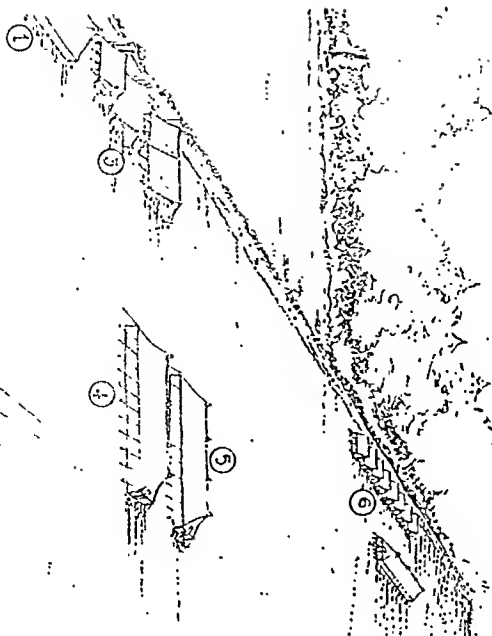
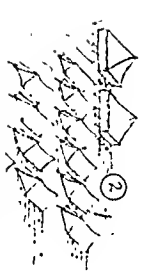
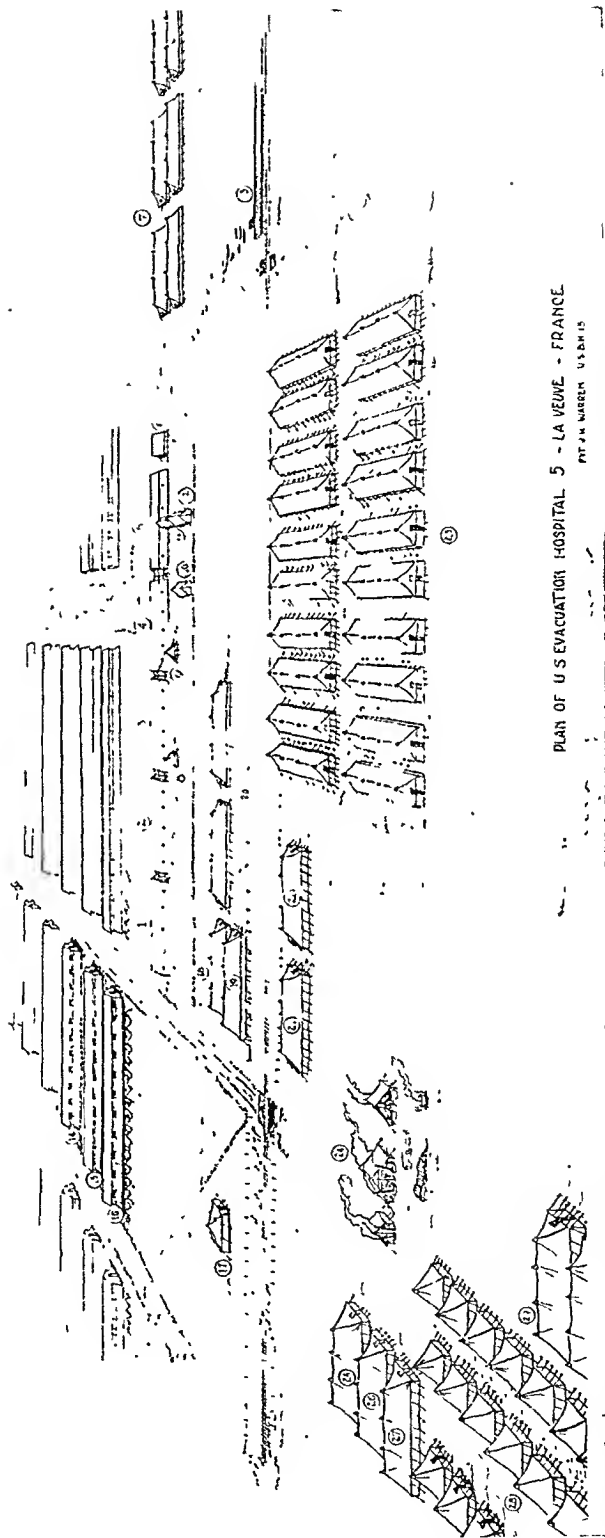


Fig. 1.—Plan of Evacuation Hospital No. 5, Villers-Cotterets, France, August 29—Sept. 14, 1918. 1, commissary; 2, personnel quarters; 3, kitchens; 4, nurses' mess; 5, officers' mess; 6, officers' quarters; 7, nurses' quarters and recreation tent; 8, surgical wards; 9, non-evacuable wards; 10 and 20, fracture wards; 11, road to evacuation platform; 12, sterilizing room; 13, dressing tent; 14, operating Bessonneau tent; 15, lighting plant; 16, pre-operative Bessonneau tent; 17, X-ray power plant; 18, X-ray Bessonneau tent; 19, 20, receiving wards; 21, headquarters; 22, Red Cross; 23, main highway; 24, quartermaster; 25, medical supplies; 27, shock ward.

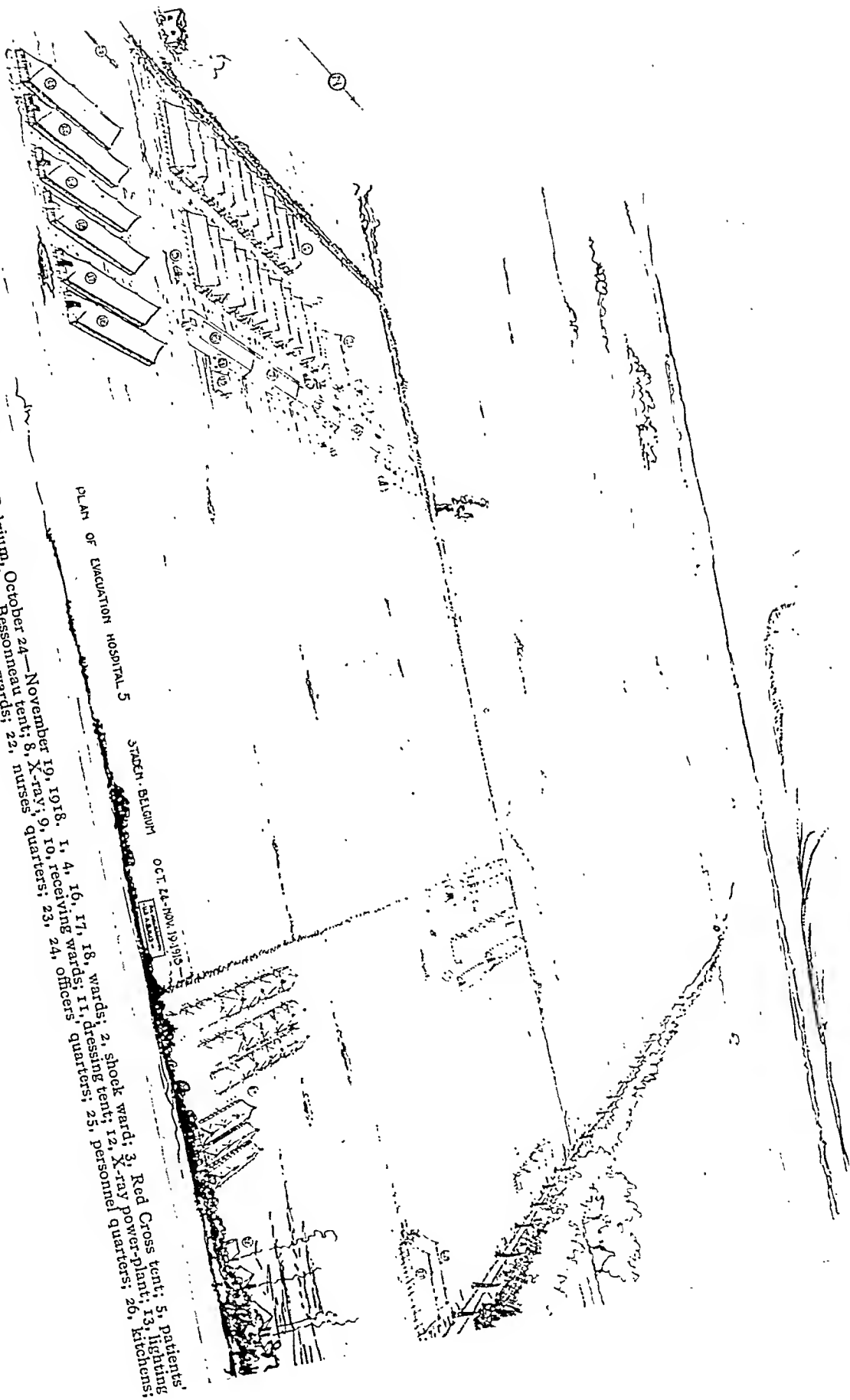


PLAN OF U S EVACUATION HOSPITAL 5 - LA VEUVE - FRANCE

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FIG. 2.—Plan of Evacuation Hospital No. 5, LaVeue, France, September 30—October 20, 1918. 1, 2, receiving wards; 3, X-ray wards; 4, pre-operative ward; 5, operating room; 6, laboratory; 7 and 23, general wards; 8, X-ray power plant; 9, lighting plant; 10, dentist; 11, sterilizing room; 12, dressing tent; 13, evacuation platform; 14, officers' quarters; 15, nurses' quarters; 16, company officers; 17, Red Cross tent; 18, shock ward; 19, dressing tent; 20, non-evacuatable ward; 21, quartermaster; 22, medical supply; 24, kitchens; 25, officers' mess; 26, nurses' mess; 27, commissary; 28, 29, personnel quarters.

FIG. 3.—Plan of Evacuation Hospital No. 5, Staden, Belgium, October 24—November 19, 1918. 1, 4, 16, 17, 18, wards; 2, shock ward; 3, Red Cross tent; 5, patients' effects office; 6, operating room; 7, pre-operative, Bessonneau tent; 8, X-ray; 9, 10, receiving wards; 11, dressing tent; 12, X-ray power plant; 13, lighting plant; 14, sterilizing room; 15, surgical supply tent; 19, 20, 21 fracture ward; 22, nurses quarters; 23, 24, officers' quarters; 25, personnel quarters; 26, kitchens; 27, quartermaster; 28, medical supplies; 29, road to evacuating platform



THE ORGANIZATION OF AN EVACUATION HOSPITAL

the evacuation platform. In the same row as these are placed three tents for fracture cases. These tents are provided with iron beds. All the remaining tents are provided with Gold Medal cots. Seventy-five beds will usually accommodate all the fractures occurring when a division is in action, providing of course that the cases can be evacuated when necessary.

The remaining 14 or 15 tents are placed in two rows on one side of the row of tents belonging to the operating suite. The tents nearest the receiving ward are reserved for medical, eye and ear cases, and the walking wounded requiring shelter. The tents in the middle are reserved for the less severely wounded.

The tent devoted to pathology is placed near the rear of and close by the operating tent, in order that the pathologist or bacteriologist may be close at hand when a bacteriologic examination of a wound is required.

The arrangement of the tents devoted to the administrative staff, to the officers, nurses, enlisted personnel and the quartermaster is demonstrated by the accompanying illustrations. The arrangements of the kitchen and mess tents are also shown.

The arrangement of the tents should be as compact as possible, as the physical demands upon the personnel should be reduced to a minimum. Compactness adds to efficiency.

The following permanently attached personnel is required to run an evacuation hospital of 500 beds with 10 operating tables. During active periods this staff should be reinforced by eight operating teams and a shock team. The teams headed by the surgical chief and his assistant should be permanently attached to the hospital. The permanent personnel should consist of 30 officers. These include a commanding officer, an adjutant, quartermaster, a surgical chief with two assistants, an assistant chief with two assistants, an oculist, a dentist, four X-ray men, a pathologist and 14 ward surgeons. The assignments should be somewhat elastic. At times, a surgical team may be reduced by one, and the man thus released may be assigned to work with more urgent demands—a nurse or an enlisted man acting temporarily in his place.

Physicians, especially trained, should not be sacrificed to duties which men without special training may do as well—often better.

Two medical officers, especially trained in sorting cases, should be assigned to the receiving ward. These officers should work 12-hour shifts. The sorting of the wounded is especially important. The wounded which can be dressed and sent back to the base, form a relatively large proportion of those received. No case about which there is doubt should be sent to the dressing tent, and no wound caused by high explosive should be sent out without an X-ray examination, unless there is no doubt that the fragment of high explosive has not penetrated.

Triage work, well done, relieves the operating surgeon of much work and reduces the amount of work which must be done in the operating room. Thus relieved, the surgeon can give more attention and render better service to those who need it most.

Two medical officers should be assigned to the tent in which dressings are removed and reapplied, antitetanic serum given, and morphine administered when necessary. These officers should each work twelve-hour shifts. They will often have time during the less active periods to work in other parts of the hospital.

X-ray Teams.—Accurate localization of foreign bodies is a *sine qua non* of success in evacuation hospital work. It saves unnecessary, often mutilating, operations. At least three, preferably four, X-ray men should be assigned to each evacuation hospital to operate the two machines with which each hospital should be provided. This is tedious, wearing work, and a man does not work at maximum efficiency much over six hours. If the wounded are not rayed rapidly enough, the work of the operating room is necessarily slowed down. There should be in the pre-operative tent at least 20 wounded, who have been rayed, and the foreign bodies localized. Much time is lost and the general efficiency of the hospital is greatly impaired if at any time operating tables are empty and the surgical teams unemployed because they are obliged to wait for X-ray examination of the wounded. The work is heavy in all active periods. In one offensive, in which the hospital with which we were connected participated, the X-ray men made 1068 localizations in 72 working hours.

It will not be necessary to have an officer detailed to the pre-operative ward; a nurse and two enlisted men should be on duty to see that the wants of the men in the ward are attended to.

SURGICAL CHIEF, ASSISTANT SURGICAL CHIEF AND OPERATING TEAMS.—Ten operating tables can be easily placed in a Bessonneau tent, which makes the best operating room. Ten teams should be provided in active periods—eight teams being detailed to the hospital when an active period is expected. Better work can be done, if enough teams are available, when they are more or less permanently attached to the hospital.

The Surgical Chief and his assistant should be experienced operating surgeons, and each should take an active part in the operative work. They should take charge of the two tables in the centre of the tent (5 and 6), if the tables are numbered from the entrance of the tent. The chief and his assistant should each work a twelve-hour shift. Working in this way, a surgical chief has first-hand knowledge of the character of the work that is being done, can keep track of those operated upon, thus determining which cases are evacuable and which are non-evacuatable; and can act as a consultant. In military, as in civil surgery, the best consultant is the active, operating surgeon. As soon as a surgeon ceases to operate and becomes a directing or administrative officer, his value as a consultant ceases. The operating surgeon, as a rule, will not value highly the opinion of a man who is not actively engaged in surgical work. There will frequently occur, during a shift, relatively inactive periods in which the Chief of the Surgical Service can visit the receiving, pre-operative and shock wards. He can gain in

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this way a rather intimate knowledge of what is transpiring in the hospital.

Surgical Teams.—A surgical team should be composed of seven: three doctors, two nurses and two enlisted men. Such a team can do comfortably the work demanded of them. A surgical team of six—two doctors, two nurses, one anæsthetist, and one enlisted man—can do the work easily.

The operative work is necessarily arduous, and the arrangements should be such that a team can do the maximum of work with the minimum of effort. Their time should be conserved. A time schedule should be put in operation which does not permit of more than eight consecutive hours of work, and provision should be made so that the team can get a full night's sleep—at least every other night. It is absolutely necessary to conserve the energies of the personnel.

An operating team should take charge of two tables. While one operation is being performed, the wounded man on the other table should be prepared. There should be such coöperation between the pre-operative and operating tent that an operating table is never empty. One of the commonest causes of loss of time and reduction in the amount of operative work performed during the day in an evacuation hospital is the lack of coördination between the pre-operative and operating tent. A table empty for a short while means a marked reduction of the amount of work done during the 23 hours that the operating room is active.

The following time schedule, which was operative in Evacuation Hospital No. 5, proved to be very satisfactory. After being posted the officer knew the hours at which his team was supposed to report, and no further notification was needed.

A surgical team on this schedule does not work over eight hours consecutively, and sleeps every other night. The following schedule became operative October 29, 1918, in Staden, Belgium:

	8 A.M. to 4 P.M.	4 P.M. to 12 M.	12 M. to 7 A.M.
Tables 1—2	Major Bailey	Lt. Col. Elting	Major Bailey
Tables 3—4	Major Stewart	Major Drennan	Major Stewart
Tables 5—6	Lt. Col. Lewis	Capt. Noble	Lt. Col. Lewis
Tables 7—8	Major Kocyan	Capt. Zimmerman	Major Kocyan
Tables 9—10	Major Long	Major Ransohoff	Major Long
October 30, 1918:			
Tables 1—2	Lt. Col. Elting	Major Bailey	Lt. Col. Elting
Tables 3—4	Major Drennan	Major Stewart	Major Drennan
Tables 5—6	Capt. Noble	Lt. Col. Lewis	Capt. Noble
Tables 7—8	Capt. Zimmerman	Major Kocyan	Capt. Zimmerman
Tables 9—10	Major Ransohoff	Major Long	Major Ransohoff

This is a most satisfactory schedule for teams can work day after day without tiring. When a team is off duty, it should not be subject to call.

Each two tables should be a unit. Instruments should be provided for each two tables. These should be carried by the Evacuation Hospital and the teams should sign for these to the head nurse when they report to

the hospital. This does lead to a reduplication of instruments, an argument, which might be raised against this arrangement, for each team would be sent out with a separate operating set if it were provided with instruments at a central distributing point. Instruments should be pooled, and this is possible when they belong to the Evacuation Hospital. When pooled, there will be no necessity for a new set up when the teams change a shift. Time will be saved in this way. Each two tables should be provided with an instrument-sterilizer. One large sterilizer for basins and pans will be enough to care for the needs of the hospital.

Fracture Team.—A fracture team of two men should be assigned to each hospital to splint the fractures. These men can save time of the surgeon as they can begin splinting as soon as the operation is finished, permitting the surgeon to start on the next case. The splinting of fractures has become so important that a special training is needed. When the splints are properly applied in the operating room, there is usually but little need for readjustment when the patient is evacuated. The splints are better applied when a fracture team is employed. As patients stand transport so much better when splints are properly applied, there can be no argument concerning the need or usefulness of such a team.

A shock team, if attached to the hospital, should be under the supervision of the most experienced surgeon. Harmony and coöperation should exist between the two. The experienced surgeon is usually the best judge of the condition of the patient and his chances of surviving an operation. The shock team, in our opinion, should be subordinate to the most experienced surgeon to whom these patients should be assigned.

An officer should be detailed at night to have general supervision of the wards. Five officers under him will be able to take care of the work to be done at this time. In case of an evacuation being necessary at night, other officers may be required, but usually six officers can easily perform all the duties required.

Nursing.—Fifty nurses, including the chief nurse and the sixteen nurses assigned to surgical teams, will be sufficient to care for the needs of a hospital such as the one being considered. Twenty-two of these should be assigned to ward duty during the day, and eight during the night. Six nurses in addition to those with the surgical teams are required in the operating room. Three of these should be on a day shift of twelve hours, and three on a night shift of the same length of time. One of these should be a supervisor of the operating room, one an assistant, and the third should have charge of the supplies. But one nurse on a shift will be required to make supplies during an active period, for the supplies provided during a lull should be sufficient to carry the hospital through the next active period. One nurse can prepare the supplies actually required during an active period, if such provision is made.

The remaining nurses are assigned to surgical teams. In some instances, a nurse must serve as an anæsthetist.

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Number and Distribution of Enlisted Men.—Because of the demands made upon an evacuation hospital during the latter months of the war, it was found necessary to increase the number of enlisted men. This was necessary because of the need of taking down and moving the hospital quickly, and of setting it up rapidly when the site selected for it had been reached.

Three hundred and twenty-five enlisted men should be attached to a 500-bed hospital.

The following are the details of enlisted men:

Company Office: Top-Sergeant, 1 typist (Pvt.), 1 orderly (Pvt.).

Quartermaster Department: 1 Sgt. 1st Cl., 2 Pvts, in office, 4 Pvts., 2 truck-drivers, 2 motorcycle drivers.

Salvage tent: 1 Corp., 1 Pvt.

Patients' Valuables and Effects: 1 Sgt. and 1 Pvt.

Medical Supply: 1 Sgt. and 1 Pvt.

Kitchen: 1 Sgt. 1st Cl., 12 cooks, 2 kitchen police.

Laboratory: 1 Sgt., 2 Pvts.

Dental Supply: 1 Pvt.

Dispensary: 1 Sgt., 1 Pvt.

X-ray: 2 Corps., 12 Pvts.

Operating Room: 1 Sgt. 1st Cl., 2 Sgts., 22 Pvts. Total number required day and night.

Overseer of Ward Orderlies: 1 Sgt.

Headquarters Office: 1 Hospital Sgt., 1 Sgt. 1st Cl., 1 Sgt., 1 interpreter (Pvt.), 1 Pvt.

Registrar's Office: 1 Sgt. 1st Cl., 1 Corp., 2 Pvts.

Number Officers and Men in Receiving Ward: Day—1 Officer, 2 Sgts., 1 Corp., 9 Pvts. Night—1 Officer, 1 Sgt., 1 Corp., 11 Pvts.

Sharp instruments should always be at hand, and one of the detachment should be detailed as an instrument sharpener. A large supply of knives should be kept on hand for débridement, which should preferably be performed with sharp knives. Some prefer scissors to the knife for this purpose. Scissors do, however, crush the tissues to some extent. Scissors are to be preferred to a dull knife.

Records.—Two typists should be assigned to the operating room, and when the operation is completed, the description should be dictated. A fairly full, but short, concise history should be given. Many of the histories in evacuation hospitals were so short that they gave no clue as to what had been done. In many instances, they were lost on the way back. The necessity of an accurate, well-written history is imperative. It is only occasionally in U. S. General Hospitals that one can find a record of the type of operation that has been performed. The field medical cards have been taken away en route to the hospital. We have under observation now 9 cases of supposed primary nerve suture. We are certain of but one of these. In this instance, the patient has a typewritten history of the findings at operation and the operation performed, but no field medical card.

The histories are of so much importance and are required so often that we believe that the field medical cards should not be given or attached to

the men. They should be carefully guarded so that they will not be lost and mutilated. They should be given to an officer or private in the hospital train who should see that these cards are delivered to the hospital to which the sick and wounded of his train are assigned.

Technic to be Employed.—Operations should, as a rule, be performed upon the litter. The patient is thus saved the discomfort of moving. After dry shaving, the skin should be cleansed with gasoline. After the gasoline has evaporated, iodine should be applied. This technic, which is simple, proved to be very satisfactory.

Wounds should not be sutured, because of the rapid evacuation. Wounds of the skull or its contents, sucking wounds of the chest, wounds of the abdomen, wounds of the knee-joint, and facial wounds may be sutured. In the remaining cases, the wounds should be left open. If patient could be watched, primary suture might be attempted.

The Evacuation Hospital as an Educational Centre.—In addition to its other function, an evacuation hospital should serve as an educational centre. Because of the opportunity offered in the number of wounded received, and the recent wounds which may be observed, it should serve as a school for developing military surgeons. The officers should first be detailed as observers. They should then become assistants, and afterward, when they have become experienced, they should become heads of surgical teams.

Evacuation hospital work is usually regarded as rough, somewhat careless work. This is a misconception. The surgery done in evacuation hospitals should be done with the same care as traumatic surgery of civil life. Judgment must be developed, and judgment can only be developed when a large number of cases of this type are observed and carefully studied. For those who are to engage in professional work, the evacuation hospital affords many more opportunities for the development of military surgeons than schools established 3000 miles or more from the seat of surgical activity. A thorough review of anatomy should be given at such schools, but the actual work in military surgery should be given in the advanced zone.

Men working in evacuation hospitals should be sent back to base hospitals from time to time, so that they may see the result of their work. By noting failure, they can change the character of the work when necessary, and add to the general efficiency of the work. A close coöperation and interchange of ideas between the officers of the advanced zone and base will add greatly to the efficiency of the service.

A hospital, such as the one just described, should be a mobile unit. One hospital of this kind can take care of the wounded of a division. In one instance that we know of, such a hospital practically took care of the wounded of two divisions.

Ten teams working 23 hours a day should never perform less than 150 major operations. Working at maximum efficiency ten teams should perform 200 major operations. The average number of operations performed by ten teams during this length of time will be about 170.

THE THREE-TABLE MILITARY OPERATING ROOM A PLAN APPLICABLE TO CIVIL HOSPITALS *

By JAMES T. GWATHMEY, M.D.
OF NEW YORK, N. Y.

At the beginning of the war, and throughout its course in some places, each surgical team had only one operating table. In civil hospitals it is almost the universal custom to provide one table for each operating room.

Under war conditions, speed is a necessity; in civil practice it is often quite as necessary and is always an advantage. The utilization of the surgeon's entire time in surgical work is the determining factor in the efficiency of any surgical operating team, and the total output of the operating teams determines the efficiency of the military hospital. The patients come suddenly, in numbers, and require immediate attention. The same may be said to apply, to a less marked degree, perhaps, to civil hospitals. The plan outlined below makes it possible for the surgeon to devote his entire time and effort to the actual surgical work; it doubles, in some instances trebles, his output, regardless of whether he be a fast or a slow operator.

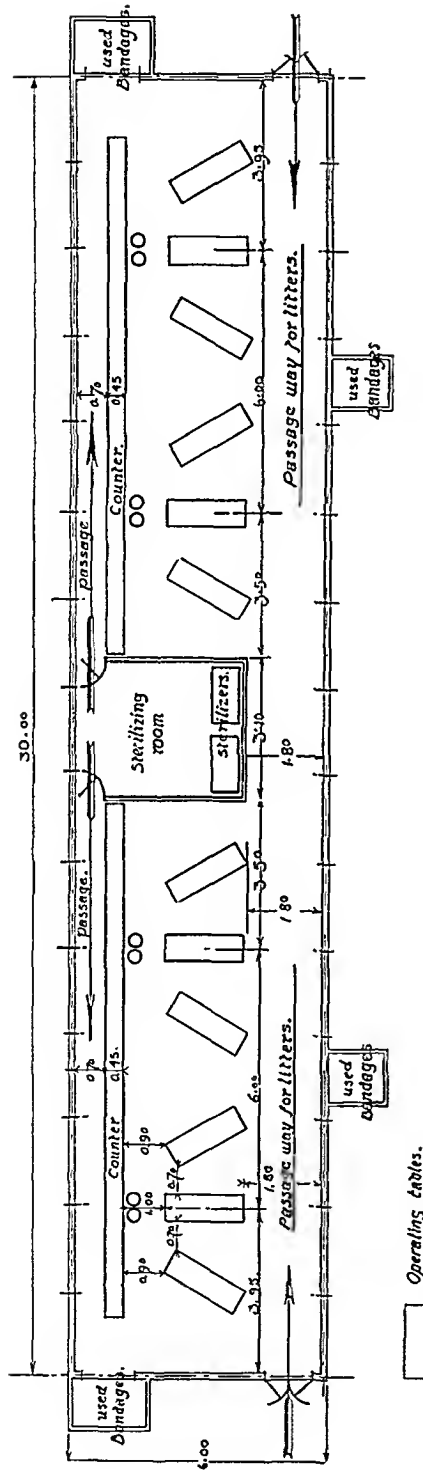
With only one operating table for each surgical team, or in each operating room, after the operation is completed, surgical dressings must be applied, stretcher bearers called, and another patient brought in, anesthetized and sterilized, before the surgeon can begin the next operation. Usually this takes from ten to fifty minutes, twenty minutes being a fair average.

Thus a surgeon, using one operating table, will lose twenty minutes or more between cases, or one hour and twenty minutes of valuable time, in operating on five patients. If these five patients represent a morning's work, in a day's work at least two hours and forty minutes of the surgeon's time will be needlessly lost. This time may be entirely recovered, by making certain changes in the operating-room equipment and technic.

Many British surgical staffs, in the war zone, adopted the plan of having two tables for each operating team. As the dressings were being applied to the first patient, the patient on the second table was anesthetized and then removed—for convenience of sterilization, etc.—to the first table. This saves from five to ten minutes, and is an improvement over the one-table plan. However, if the second operation proves to be a very short one, this time may be lost again before the third patient can be brought in, anesthetized and sterilized, and the operation begun.

The advantage of two tables, with the addition of nitrous oxide, oxygen

* Authority to publish granted by the Surgeon General, U. S. A.



○ ○ Nitrous Oxid and Oxygen Tanks--Large Size with Apparatus attached.

FIG. 1.—Filed hospital operating barrack, American Red Cross, 4 Place de la Concord, Paris, Bureau de Construction, February 9, 1918.

and ether as the anæsthetic, is shown in the following record of a week's work of one anæsthetist at a base hospital, working with a number of surgeons, and where *speed was not an essential*: September 25, 11 cases; September 26, 17 cases; September 27, 16 cases; September 28, 16 cases; September 29, 12 cases; September 30, 10 cases.

This shows an average of $13\frac{2}{3}$ cases per day of seven to eight hours. The best day, under the same conditions, when *speed was essential*, was 34 cases.

The average for this anæsthetist, working under similar conditions, with chloroform and ether, was eight to nine cases per day. In fact, with chloroform and ether the work was so much delayed that other anæsthetists had to be called in. Environmental technic, and not the anæsthetist, is a contributory factor in the successful dispatch of surgical cases.

The *efficiency problem*, therefore, involves changes in the operating-room technic, in the anæsthetic, and in the surgical team, which have already proved entirely practical for one unit, and which, therefore, can be applied to an entire operating theatre. The changes are as follows:

1. Each surgical team to consist of a surgeon, one anæsthetist, two nurses (one sterile), and two surgical assistants or orderlies.
2. Two sets of surgical instruments, such as are commonly used in all operations, *viz.*, knives, scissors, retractors, artery forceps, etc.
3. Nitrous oxide, oxygen, and ether as the anæsthetic.
4. The surgeon to wash and then sterilize his rubber gloves without changing, add sterile cuffs, and have a sterile towel pinned over gown.
5. Three operating tables,¹ so arranged that the anæsthetic mask can be changed from one patient to the other, *without having to move the nitrous oxide and oxygen tanks*,² and without having to move the tables.

The following plan (see chart), in collaboration with Mrs. Mae Noe Daly, of Autochir No. 7, of the French Army, is drawn to scale, and shows the position of the tables and anæsthetic outfit, by which the surgeon's time can be utilized to the utmost, and full advantage taken of the rapid induction of anæsthesia, and the elimination of the anæsthetic.

No special arrangement of hut, tent, or operating-room is essential in order to utilize the three-table plan. Three tables can be placed anywhere. In the light of our experience, a mobile hospital, with elaborate sterilizing outfit on wheels, and with only one operating table for each surgeon, is an unwise expedient.

I have witnessed eight full teams, each team having only one table, occupied all night with one hundred patients, alternately working and loafing (of necessity, loafing) as each patient was carried out and another brought back, placed on the table, prepared and anæsthetized. The same

¹ Four tables were tried, but no more time was saved than when three tables were used; the fourth table was in the way.

² Only the largest sized nitrous oxide (3200 gal.) and oxygen (1200 gal.) tanks are recommended.

hundred patients could have been operated on more satisfactorily in the same length of time by four teams with three tables each, and the efficiency of four full teams would have been saved for the next day's work.

Soldiers from the battle line, as a rule, show no antipathy toward being placed upon an operating table next to one in active use. (In civil life this aversion may be overcome by preliminary medication, and by placing a towel or gauze over the patient's eyes.) If any interest whatever is shown, it is only a mild degree of curiosity. Usually they have had an unknown quantity, one-half grain of morphia, before leaving the front line. No preliminary medication, therefore, is advisable in an evacuation hospital.

OPERATIVE TECHNIC

The patient on the first table is anæsthetized and operated upon. Instruments and sterilization for this table are on two shelves running the length of the hut, immediately to either side of the anæsthetic tanks, and within easy reach of the nurses. While the first patient is being operated upon the second patient is being prepared (as far as his injuries permit) by the second nurse. As the dressings are called for for the first patient, the anæsthesia ceases. *The dressing and bandaging is done by the nurse.*

While the next patient is being anæsthetized the surgeon is rinsing and sterilizing his rubber gloves, *without removing them*; a sterile towel is pinned over his gown, and sterile armlets are pulled up and pinned in place. The operation upon the second patient now begins (three minutes or less). Instruments for this second patient are placed on a sterile towel, on a part of the patient's body not to be operated upon. The second operation may, and sometimes does, begin before the first patient is removed from the table.

The first nurse now prepares and sterilizes the third patient. Sterilization and instruments for the third patient are upon a shelf within convenient reach of the nurse. At the proper time this patient is anæsthetized, as was the second, the surgeon sterilizing as before, and then operating. By this time another patient has been brought in and placed on the first table. This patient is prepared for operation by the nurse from table two, and the above sequence is followed continuously.

The immense advantage of this plan, plus team work, is shown in the record of a certain team, consisting of one surgeon, one anæsthetist, and one orderly. Starting at 2 P.M., and continuing until 8 P.M., with one hour out for tea, 24 cases were operated upon. It is fair to assume that with two sterile nurses and two orderlies, and utilizing the *entire* time of the surgeon, each team should average 10 to 50 cases per day. Four teams should average 75 to 100 cases per day.

When nitrous oxide and oxygen are not available, the same plan may be followed by adding two anæsthetists to each unit. This insures the even working of the plan.

While this plan is intended primarily for a casualty clearing or evacuation hospital, it is entirely practical for a base hospital where saving time *for the patient* is not such a vital element. But here some preliminary medication should be given, to insure the even working of the plan.

When morphia is contraindicated, for any reason, "oral analgesia"³ may be used with assurance. This may be used only in advanced hospitals, regardless of whether morphia has been given previously. It is *especially useful in painful dressings* or slight operations. When employed as a preliminary medication to operation, either with or without morphia, the required relaxation is obtained with much less anæsthetic than when this medication is not used. The "open method" of nitrous oxide, oxygen, and ether may be used when this medication is given.

The method of administration is as follows: One ounce of port wine is placed in a glass, and the "analgesic" in another glass. The patient takes a small mouthful of the wine, holds it about 15 seconds, rinsing the mouth so as to get the aroma in the upper air passages and the taste well established, and then swallows the wine. The "analgesic" is then taken, and is followed *immediately* by the remainder of the wine. Patients are able to take food and water shortly afterward, and even in patients much exhausted by infection there have been no deleterious after-effects. While it is well not to give the "analgesic" immediately after a meal, no special preparation of the stomach is necessary.

The following formulæ have been used clinically with success:

1. Ether,

Liquid paraffin, āā	drams iv
Aq. menth. pip.	m v

NOTE.—This may be repeated with the port wine as a sandwich in 15 minutes, if necessary. "Rum" may be used instead of port wine, and is preferred by some patients. The analgesic effect is better with rum than with port wine.

2. Ether,

Paraldehyde, āā	drams ii
Liquid paraffin	drams iv
Aq. menth. pip.	m v

NOTE.—Not as pleasant to take as the first mixture, but more powerful, the analgesia being more prolonged.

3. Ether,

Chloroform, āā	drams ii
Liquid paraffin	drams iv
Aq. menth. pip.	m v

NOTE.—A better analgesic effect than the two preceding mixtures, but more apt to be followed by vomiting than the others.

³ Gwathmey and Karsner: "General Analgesia by Oral Administration." Jour. A. M. A., April 6, 1918, vol. lxx, pp. 993-995; Brit. Med. Jour., March 2, 1918.

SUMMARY

1. By fully utilizing the surgeon's time, the output of any surgical team is more than doubled.
2. Possibility of infection in advanced hospitals due to delayed operation is reduced to a minimum.
3. The number of surgeons in any hospital is reduced by one-half.
4. The plan, with modifications according to the circumstances, may be utilized in civil hospitals as well as military.

BOOK REVIEW

COLLECTED PAPERS OF THE MAYO CLINIC. Rochester, Minnesota. Edited by MRS. M. H. MELLISH. Volume x, 1918, October, cloth, pp. 1196, Philadelphia, W. B. Saunders Co.

These contributions to medical literature from the Mayo Clinic have annually appeared since 1910. That first volume was reviewed in the *ANNALS OF SURGERY* of 1911, vol. liv, p. 718. Again the series was noticed in 1915, vol. lxi, p. 765.

The present book, which is the tenth successive annual volume, commands attention on account of the number of contributors, forty-six in number, and of the number of papers contributed, ninety-five in all. With but few exceptions these papers have been read before medical societies and have already been published in medical journals.

The widely extended territory represented in the various medical organizations thus addressed in a single year, and the medical journals to which the articles thus read have been contributed is most noticeable. The American Medical Association naturally heads the list, and in its journal were published twenty-four of these papers. The Minnesota Medical Societies naturally follow next in order of frequency and are credited with twelve papers which were published in the *Minnesota State Medical Journal*.

Of the more important general medical organizations of the country there appear the American Surgical Association, the Congress of the American College of Surgeons, the American Association of Physicians, the Southern Surgical Association, the Southern Medical Association, the American Society of Clinical Investigation, the American Association of Anæsthetists, the American Public Health Association, the Catholic Hospital Association, the International Association of Medical Nurses, the Western Surgical Association, the Ontario Medical Association, the Saskatchewan Medical Association, the Tristate Medical Association of Washington, Oregon and Idaho, the Medical Associations of the States of Iowa and Illinois, of Montana, Mississippi, Louisiana and Texas, the Chicago Medical Society, the Olmsted County Medical Society, the Chicago Urological Society, and the Clinical Club of the Mayo Clinic.

Of the medical journals in which these papers were published in addition to the two journals already mentioned, the *ANNALS OF SURGERY*, *Surgery, Gynecology and Obstetrics*, and the *American Journal of the Medical Sciences* appear to have been the most frequent vehicles chosen by the authors for communicating with the general profession. In addition to these journals, in some eighteen others one or more of these articles were published.

The papers are classified into the following sections: I. Alimentary Canal; II. Urogenital Organs; III. Ductless Glands; IV. Heart; V. Blood; VI. Skin and Syphilis; VII. Head, Trunk and Extremities; VIII. Nerves; IX. Technic; X. General.

A large number of the papers, more than half, are brief notes, of ten pages or less in length. Of the more elaborate papers may be mentioned the three papers on various aspects of syphilis, *viz.*: "Syphilis of the Stomach," "The Röntgenology of Syphilis," and "Medical Coöperation in the Problem of War Syphilis."

The paper by Eusterman on "Syphilis of the Stomach" is especially worthy of note and study. It contains data and deductions arrived at in a study of forty cases, in twelve of which the patients came to operation. The composite clinical picture which he draws of the condition is of "an adult averaging thirty-five years of age. Usually the gastric disturbance averages a little more than two years' duration, characterized chiefly by pain, vomiting and flatulency coming on fairly promptly after taking food. The course is progressive, with gastric chemism and X-ray findings more like that of carcinoma. The patient is undernourished, but not cachectic, may be somewhat anæmic, and there is usually absence of any palpable gastric mass. The gastric lesion is invariably extensive, is occasionally localized in the pyloric area, with only a slight tendency to produce stenosis—such characteristics, in conjunction with a positive Wassermann reaction, or with a history of infection and other clinical signs of syphilis, are strong presumptive evidence of specific gastric disease." The important practical bearings of these observations are such as to enlist the interest of every thoughtful practitioner. They throw a light into a hitherto neglected corner of differential diagnosis, and should be supplemented by the studies of practical surgeons quite as much as of specialists in syphilology.

"Clinical Studies in Cutaneous Aspects of Tuberculosis," by J. H. Stokes, is an elaborate and able paper, and supplements materially the discussions of syphilitic conditions. The subject to which most space—fifty-nine pages—is given in this volume is "Studies in Cholesterol," by Georgine Luden. The relation of the cholesterol content of the blood in the cytology of the blood as influenced by food first engages attention, ending in the conclusion that the influence of the food on the chemical composition of the blood increasing or diminishing the amount of cholesterol therein is clearly demonstrated. The important corollary to this is the thesis that "in persons predisposed to carcinoma an increase of the cholesterol and a weakening of the lymphoid defense, such as may occur with the prolonged use of a diet adapted thereto, may perhaps result in the development of carcinoma," and the converse that "dietetic measures calculated to reduce the blood cholesterol and coincidentally increase the lymphoid defense" may yet prove to be of value in the treatment of carcinoma. It is to be hoped that the speculation of the author may bear

BOOK REVIEW

clinical fruit. It is difficult to imagine a more epochal event than would be the demonstration that diet could be made to serve as a curative agent in carcinoma. This paper by Doctor Ludens will give aid and comfort to those practitioners who for many years have claimed to be able to favorably influence the course of a cancer by what they allowed the patient to eat!

The book as a whole bears testimony to the extent and diversity of the work of the Mayo Foundation, which organization is beyond question the most important event in the medical world thus far of the twentieth century.

Though this clinic appears to be a contribution to coöperative medicine, closer analysis shows it to be a wonderful example of individualism in its inception, growth and full development. Medical sociologists may easily differ in the views which they take of the lessons to be derived from and the influence exerted by the Mayo Clinic, while the average practical man remains content to take pride in it and to employ the helps which it is so continuously bringing to him in the solving of his own problems.

LEWIS S. PILCHER.

CORRESPONDENCE

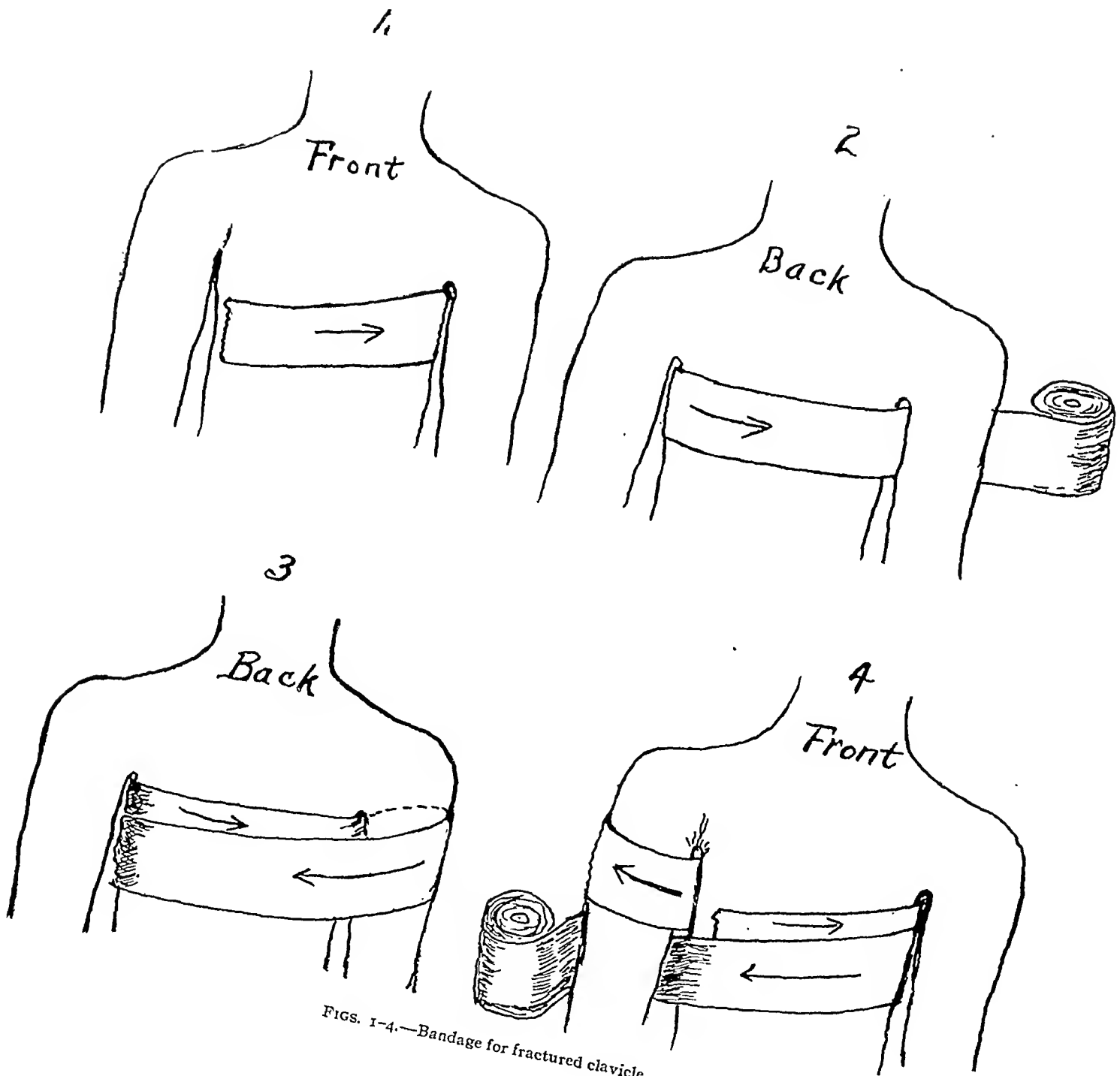
SIMPLE BANDAGE FOR FRACTURE OF THE CLAVICLE

EDITOR ANNALS OF SURGERY:

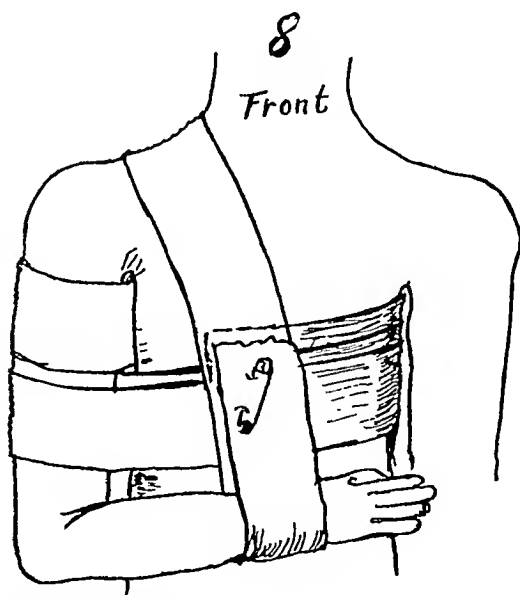
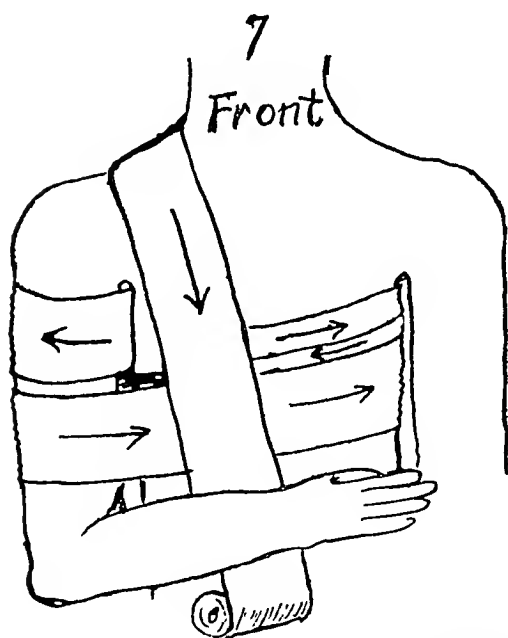
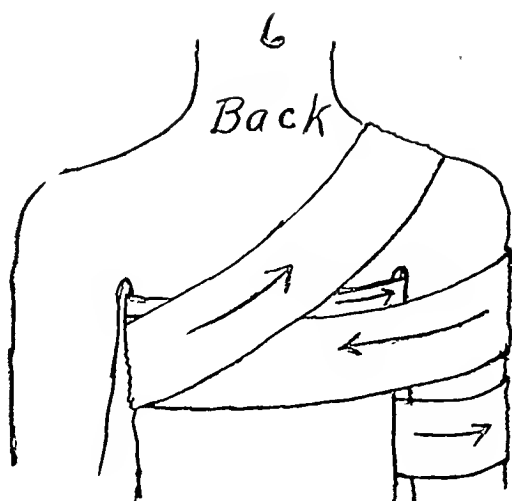
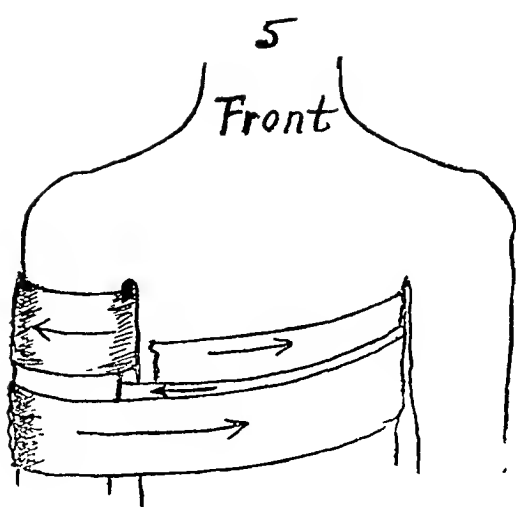
The bandage described in the accompanying illustrations was evolved during a service in a hospital having a large number of fracture cases coming to the out-patient dispensary. These patients were mainly workmen and children, and it was hard to get them to observe any instructions carrying restrictions on their activity, the result being that they were continually coming back to the dispensary after the first few days of convalescence for redressings. This consumed a vast amount of time and dressing material. To obviate this and to meet the sources of trouble from loosened dressings, soreness and pain over the tendons of the pectoral muscles when the posterior figure eight was used, creasing and pulling over tender areas by slipping adhesives at other times, I began to hunt for some better means of bandaging the clavicle fractures, which seemed to be the most troublesome. One day while attempting to put on a bandage I had read up somewhere a few days previous I got lost before it was half done, but kept at it until at the finish I had put on the one depicted herewith. Its object is to hold the point of the shoulder back, the elbow forward, to allow the forearm to act as a weight holding the fragments down and in place, and finally to completely immobilize the arm and shoulder without binding or discomfort to the patient. A four-inch flannel bandage is used and a single safety pin at the point shown in the last illustration, and passing through all the layers at this point, secures the whole bandage. Under the last turn of the bandage coming down over the clavicle a small layer of cotton or other material may be placed to make whatever holding pressure is desired over the ends of the fragments.

The end results in all my cases were excellent, many patients not returning for two or three weeks, because they had had no discomfort. Whenever there was any tendency of any part of the bandage to crease, a strip of adhesive over the outside at that point after smoothing it out almost always remedied the trouble. Since there is only one smooth layer of bandage over each part, it will be found especially serviceable in hot weather.

L. A. KENNEL, M.D.,
Lieut., Med. Corps, U. S. Navy.



FIGS. 1-4.—Bandage for fractured clavicle.



FIGS. 5-8.—Bandage for fractured clavicle.

THE USE OF VEINS AS A REINFORCEMENT AND SUPPORT OF NERVE SUTURE

EDITOR, ANNALS OF SURGERY:

Most writers advocate the perineural stitch in end-to-end suture of nerves, justly fearing, it seems to me, any traumatism of the nerve bundles distal to the line of suture. A few advocates of the transneural stitch, among them Sherren and Wilms, claim little traumatism to the nerve paths in carrying a fine needle directly through the whole nerve.

The disadvantages of the perineural stitch are: First, that it does not give an absolute, end-to-end, approximation, when the nerve is put under any tension. The very pulling of the nerve together by the perineurium tends to skin the perineurium over the nerve bundles and leaves the nerve bundles short of the ends. When stitched and under tension, the nerve fibres retract and a little gap is left between them. The transneural stitch may certainly overcome this gap, but this stitch traumatizes the nerve fibres. Second, if too many stitches are used at the juncture of nerve ends, the scar tissue is apt to be excessive.

With considerable loss of the nerve substance, from injury or resection, the gap may be difficult to overcome and put the suture under tension. Actually the gap may have to be bridged by the interposition of a fascial sheath, as performed by Dean Lewis, of Chicago, or by a constructed bundle of sensory nerves, successfully performed by Leo Mayer, of New York.

While I have no terminal results to prove my method, more than the immediate application, I venture to suggest the use of veins to reinforce and support the end-to-end perineural suture, to invest the bundles of sensory nerves and support the two lines of suture and as a sometimes substitute for the fascial sheath, to bridge the gap between nerve ends.

Let it be understood that I am aware of the fact that quite a breech between nerve ends can be gained by flexion at the elbow, knee, wrist and ankle, but this in no way contradicts as secure a suture and support of suture of nerve ends as possible.

Moreover, when the nerves are united, there is left a ring made up of the united perineurium and the perineural stitches, which is to come directly in contact with the surrounding scarring in the soft parts, if not involved in bone callus. The scar between the nerve ends can easily mingle with the scarring in the surroundings.

Veins large enough to cover any peripheral nerves, except the sciatic, can be found near the site of nerve suture, near the elbow or knee; the median basilic and median cephalic and branches of the saphenous. The veins easily stretch in diameter to accommodate the nerve. The veins should be taken, preferably, with their connective tissue sheath.

Fig. 1 is an attempt to represent, in diagram, a section of a vein investing one of the ends of the nerve to be sutured and about to be pulled over the juncture of the two nerve ends, when united end-to-end by perineural sutures. Four sutures are seen, two at each end of the vein and two perineural stitches, piercing the perineurium of the two nerve ends. Traction sutures are not shown.

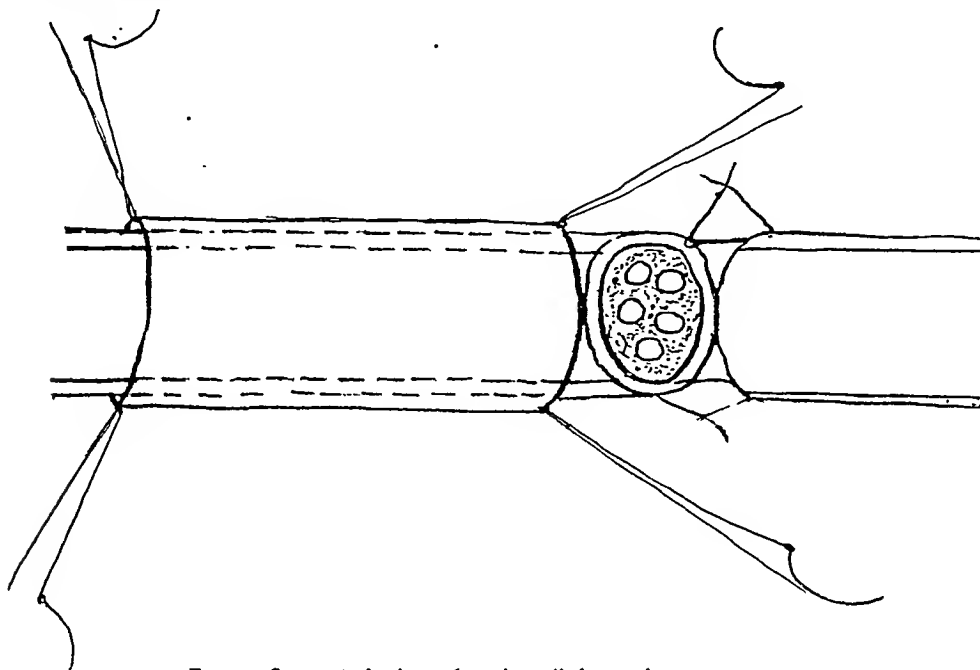


FIG. 1.—Segment of vein ready to be pulled over the nerve suture.

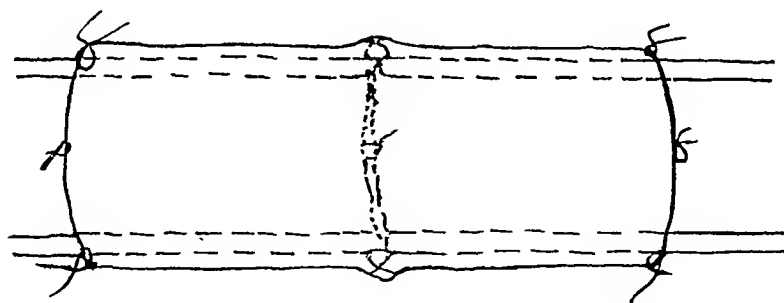


FIG. 2.—The suture completed and enclosed within the vein sleeve.

Fig. 2 would represent the nerve ends, sutured end-to-end by perineural stitches and the vein drawn over the suture line and then attached, proximal and distal, to the line of nerve suture, to the perineurium. All stitches are taken through the long axis of the perineurium.

The procedure is carried out as follows: By means of two, three or four fine silk sutures, the vein is pulled over one end of the nerve trunk, the nerve suture made, the vein pulled over the suture line. The vein is first stitched to the perineurium on one side of the suture line and then,

under stretch and at the same time forcing the nerve ends together, the other end of the vein is stitched to the perineurium, on the other side of the suture line. This serves to draw the nerve ends together and put the strain on the vein and perineurium, proximal and distal to the line of nerve suture.

In the same way, the vein, instead of a roll of fascia, may be used to span a gap between the two nerve ends.

If several strands of sensory nerves, united into a bundle, are to be used to span the gap between the nerve ends, the bundle of sensory nerves is first drawn through the vein and both ends of the vein turned back on themselves. Then each end of the sensory nerve bundle is stitched to each nerve end and the two ends of the vein are drawn, up and down, over the two lines of nerve suture and stitched to the perineurium, proximal and distal, respectively, to the upper and lower junctions of intermediary sensory nerve bundle and the two ends of the nerve trunk.

ADDISON G. BRENIZER, M.D.

Charlotte, N. C.

A METHOD FOR THE PREVENTION OF HÆMATOMA FORMATION AFTER OPERATIONS FOR UNDESCENDED TESTIS

TO THE EDITOR OF THE ANNALS OF SURGERY:

In operating for undescended testis by any of the approved methods a very frequent, and perhaps distressing complication, is an extensive bleeding from the bed newly created in the scrotum for the reception of the transplanted testis. Indeed, the amount of bleeding—a certain amount is almost sure to occur in all cases—is on many occasions sufficient for the formation of an unexpectedly large hæmatoma, which causes an extraordinary dilatation of the appropriate side of the scrotum, and in the midst of which the contour and outlines of the testis are entirely lost. Under such conditions the period of convalescence is considerably lengthened; and whatever extremely little chance the organ may have for regaining any of its function is jeopardized by the secondary contraction of the gathered blood-clot and a subsequent atrophy.

For a number of years I have arranged my technic in operating for undescended testis so as to eliminate altogether this unwelcome complication. The part of the method of operating by which this is accomplished is carried out as follows: Immediately upon making the customary incision above Poupart's ligament, a passageway is tunnelled subcutaneously from the lower angle of the wound downward into the scrotum to its lowermost part, at which point the transplanted testis is to find its final resting place. The resulting cavity is dilated with dressing forceps and fingers until its dimensions are several times larger than will ultimately be necessary; immediately thereafter it is packed tightly and voluminously with dry gauze. The packing

is permitted to remain *in situ* until the termination of the subsequent steps of the operation directed towards curing the usually accompanying hernia, and for lengthening the cord sufficiently to permit the testis to settle without any tension at the lowermost point of the newly-created cavity in the scrotum. By that time the entire operation has been completed with the exception of the closure of the skin incision; and depending on the presence, or absence, of technical difficulties, the packing will have remained in its original position for a variable length of time always longer than fifteen or twenty minutes. The packing is then withdrawn, the testis is slipped into its proper position in the scrotum, and the skin incision is closed. The dressing applied does not include the scrotum.

In the cases in which it has been my privilege to operate according to this method, the postoperative course has never included any hæmatoma formation in the scrotum. The most that I have seen has been a comparatively slight discoloration of the skin, but the scrotal tissues were soft and not infiltrated, the two halves of the scrotum were approximately of the same size, the transplanted organ could be definitely outlined as it rested in the bottom of the scrotal pocket, and the amount of testicular swelling was never more than would ordinarily be expected to follow the necessary handling of the organ.

The packing prevents any bleeding (1) by its mechanical pressure; (2) by allowing sufficient time for the skin capillaries to become occluded by clotting, and (3) by overdistending the dartos so that when the packing is withdrawn a certain amount of contraction takes place.

This technic can be incorporated into any method of operation for undescended testis.

ABRAHAM O. WILENSKY, M.D.,

New York City.

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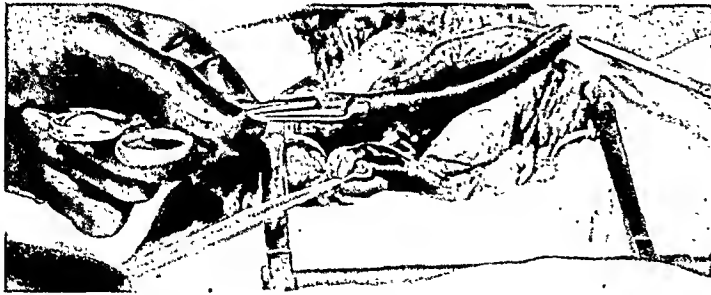
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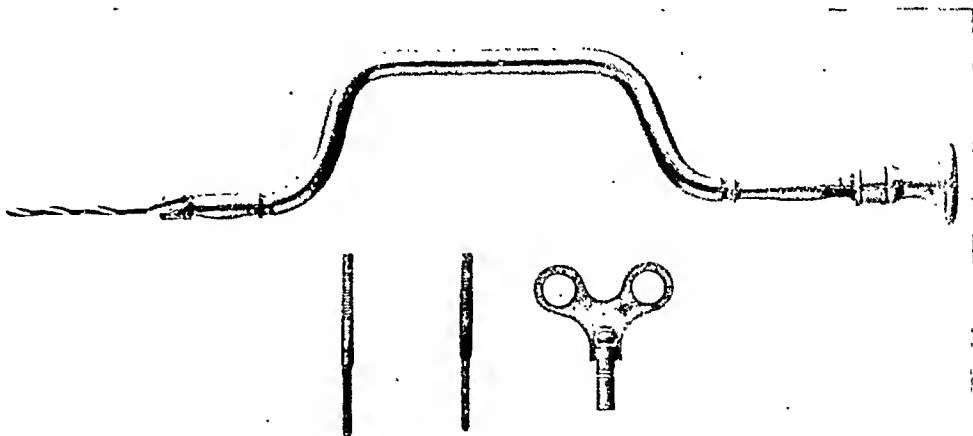
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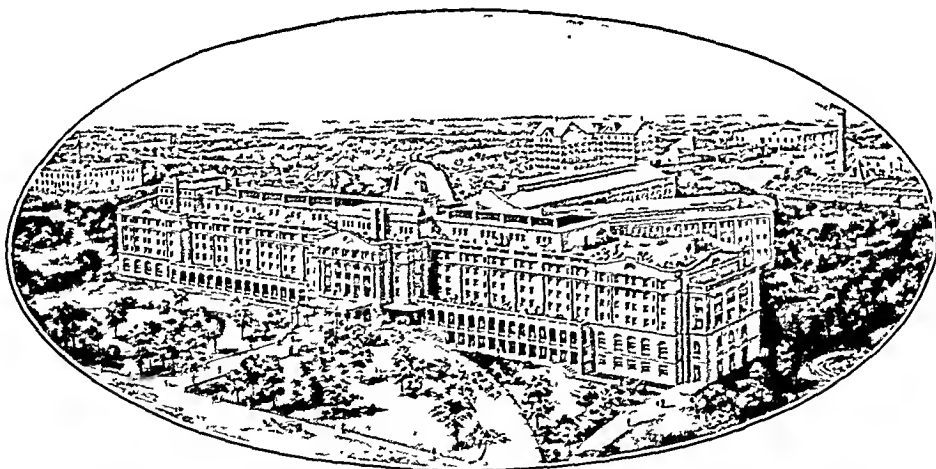
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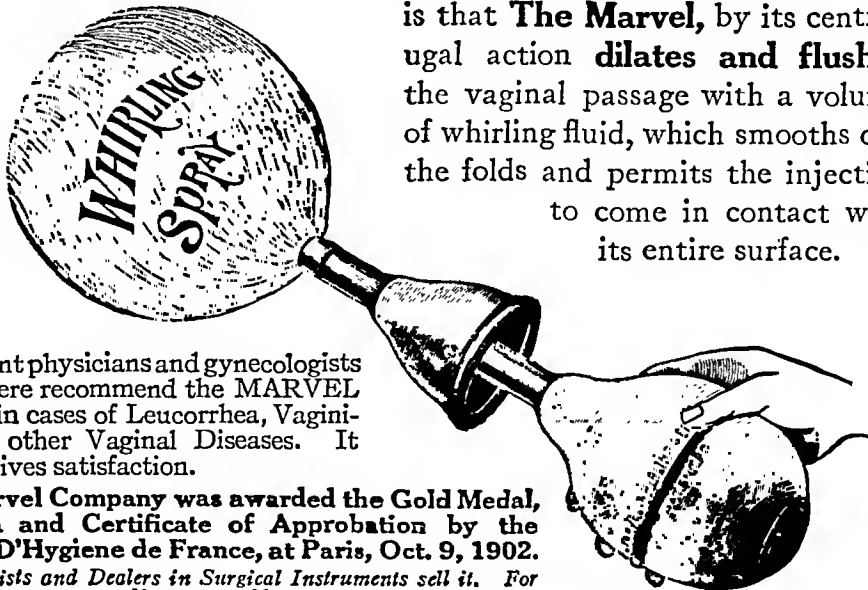
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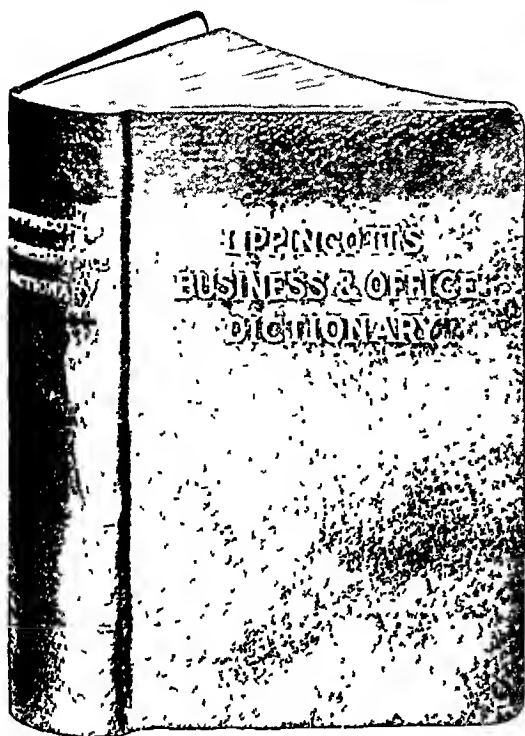
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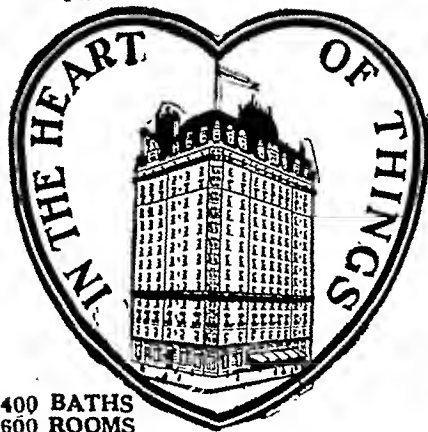
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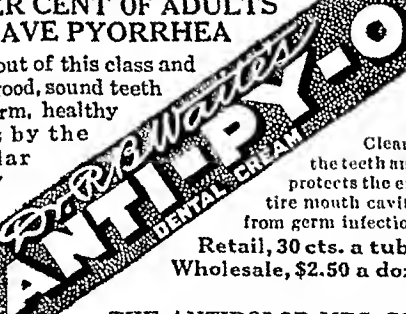
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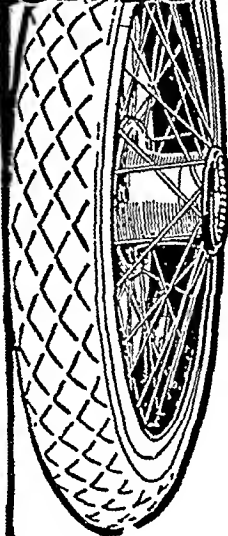
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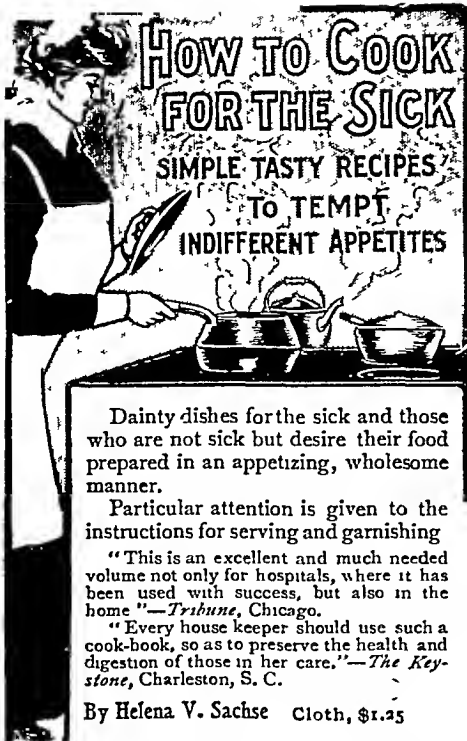
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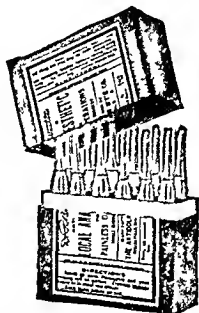
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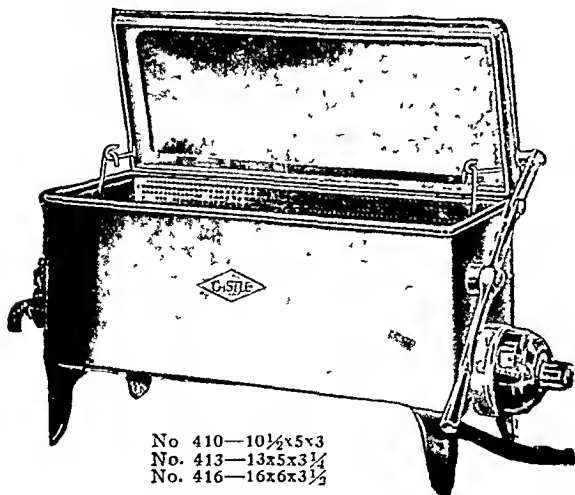
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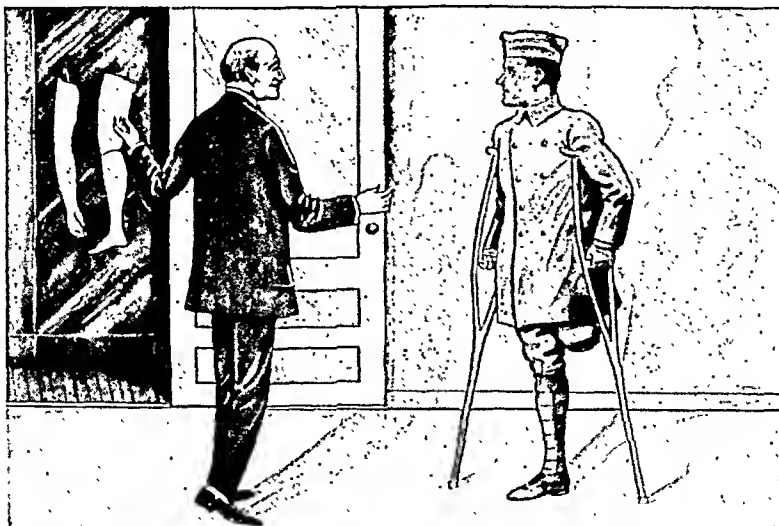
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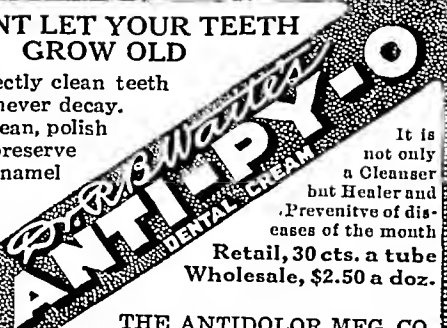
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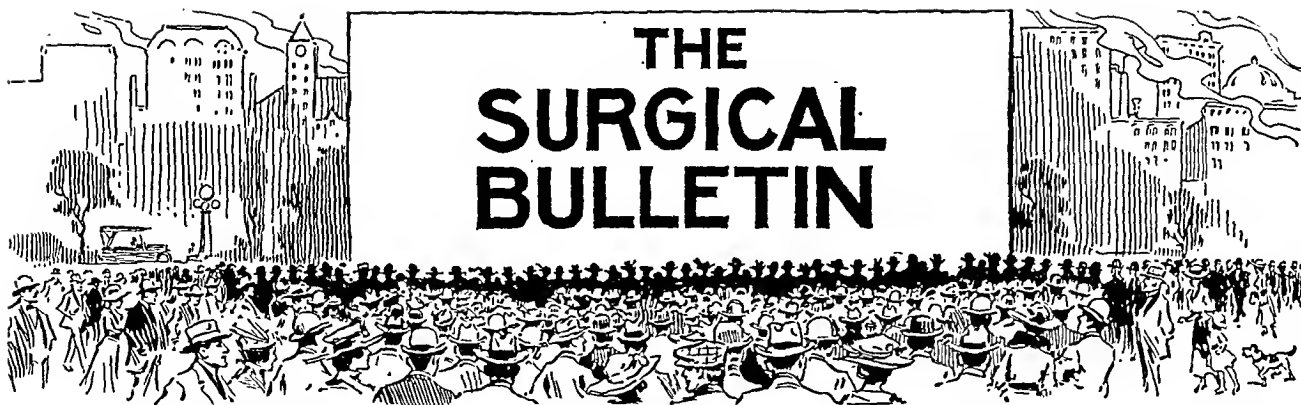
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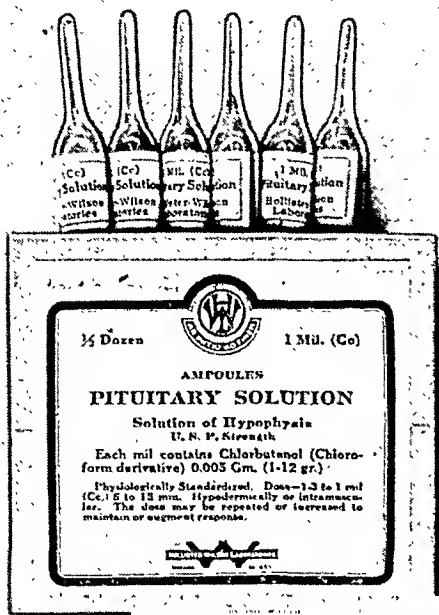
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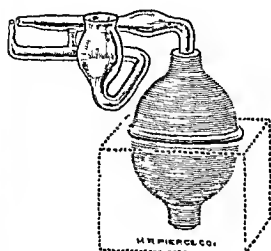
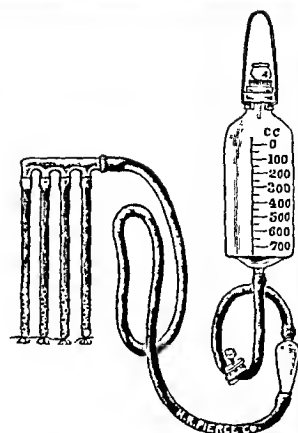
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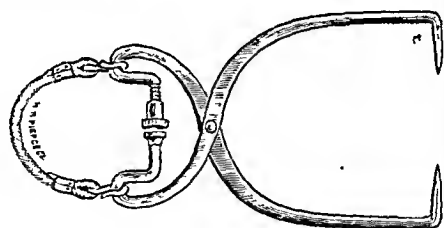
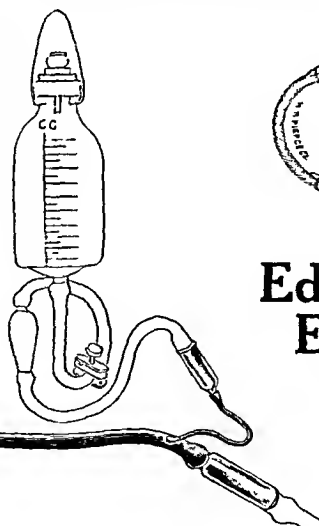
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Read before the Oregon State Medical Society, June 21, 1919. See page 231, August, 1919, Annals of Surgery.

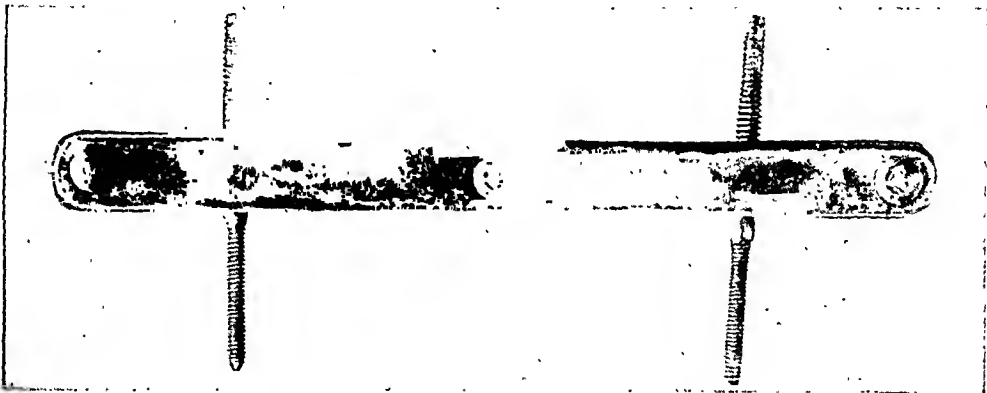


PLATE 2. Side view of Bone Clamp.

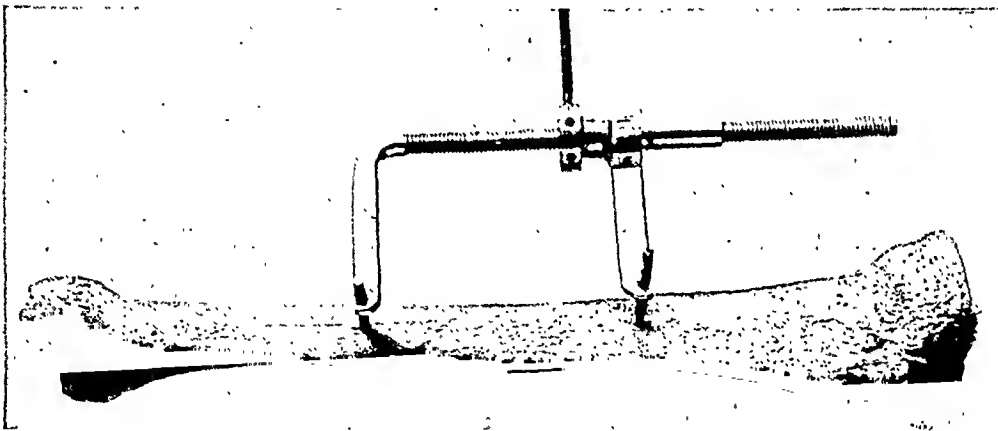


PLATE 5. Turnbuckle in position for applying extension.

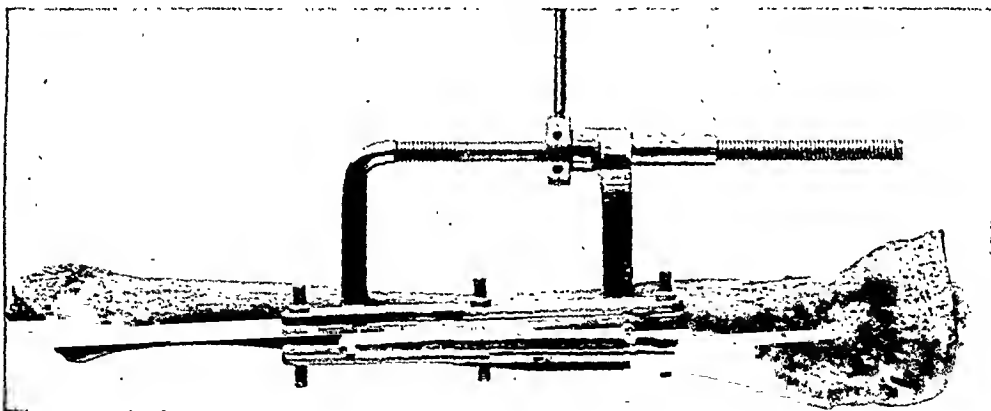


PLATE 6. Bone Clamp in position before removal of Turnbuckle.

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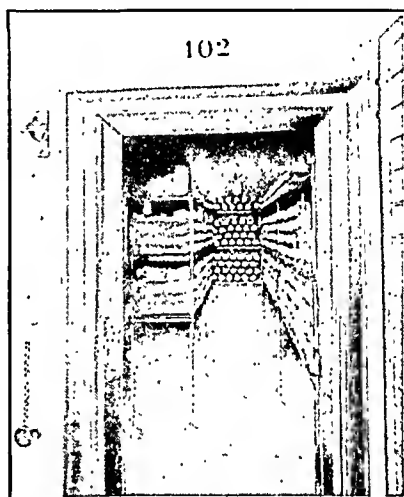
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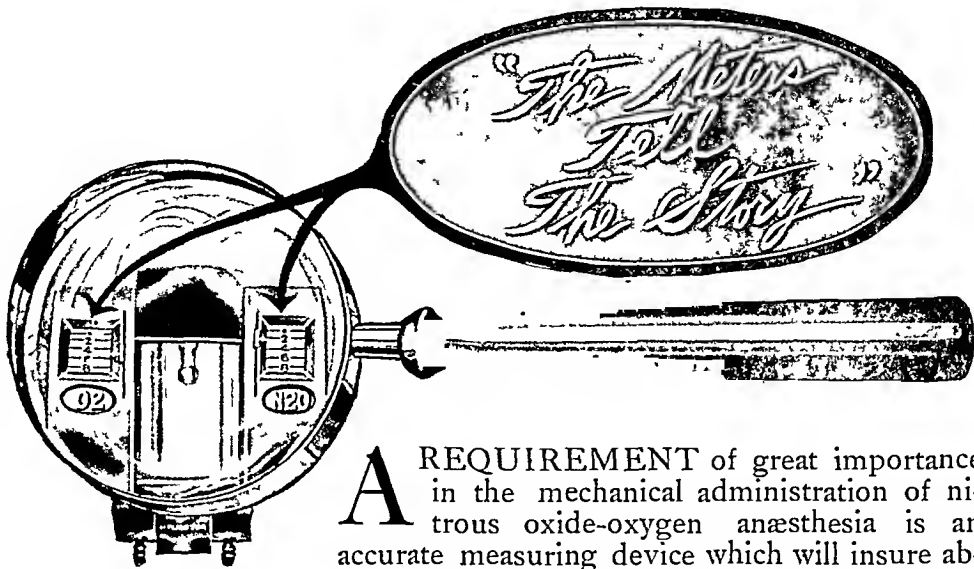
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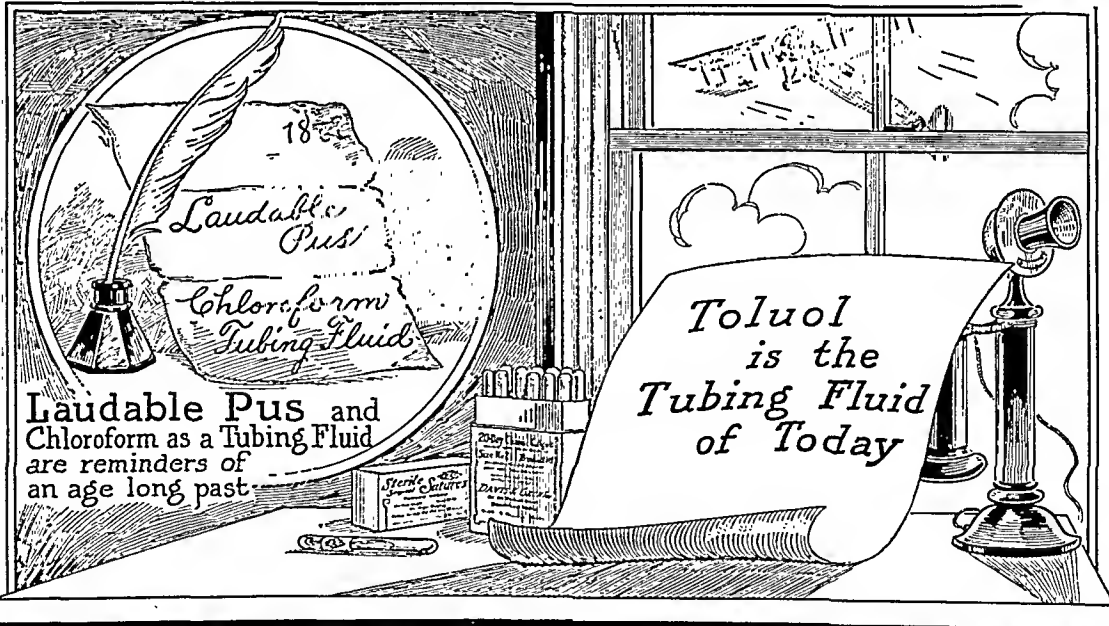
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ANNALS *of* SURGERY

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DECEMBER, 1919

No. 6

FURTHER OBSERVATIONS ON THE CONSERVATIVE TREATMENT OF SARCOMA OF THE LONG BONES*

BY WILLIAM B. COLEY, M.D.
OF NEW YORK, N. Y.

THE present paper consists chiefly of a report of the cases of sarcoma of the long bones that have come under my personal observation during the past five years, with a brief review of cases previously published.

In a previous paper on this subject I have strongly advocated the conservative treatment of sarcoma of the long bones, and the cases observed during the past years, I believe, furnish further evidence in justification of conservative treatment. It might seem unnecessary to present this evidence, were it not for the fact that the majority of surgeons at the present time, including many men with wide surgical experience, have not fully accepted the principles of conservative treatment, and are now sacrificing many limbs which might be saved under conservative treatment.

In a paper read before the Southern Surgical Association in December, 1917, I published 200 cases of sarcoma of the long bones personally observed. Since that time 50 cases have come under my observation.

In the former papers I have discussed at considerable length the question of diagnosis. In the present paper I only wish to emphasize certain points which, larger experience has convinced me, deserve special note.

First, the element of pain. Pain, especially of a deep boring character, steadily increasing in severity, is often one of the earliest and most important signs of sarcoma of the long bones. Many of these patients are first treated for some rheumatic condition, until the disease has progressed sufficiently to produce a palpable tumor. Persistent pain is often present for weeks or months before there is a palpable tumor or the X-ray discloses any evidence of a new growth.

Pain is a more important symptom in periosteal growths than in the central tumors. The latter often attain considerable size, with little or no pain. I recently had under observation a case of periosteal sarcoma of the upper portion of the femur, in which severe pain was not only the earliest symptom, but required quite large doses of morphine before a swelling could be detected. Later on, a slight swelling was noticed in the outer aspect of the left femur, just over the trochanter. The X-ray

* Read before the American Surgical Association, June 16, 1919.

at this time showed a slight thickening of the periosteum which, in conjunction with the clinical symptoms, made the diagnosis of periosteal sarcoma probable. Under the toxin treatment alone, the pain ceased almost immediately; later a local application of massive doses of radium was made. Four weeks later the pain returned and increased in severity. An exploratory operation was done, showing an extension of the disease downward and marked involvement of the periosteum, of the extent of which the X-ray examination had given little evidence. The tumor apparently started in the under-layers of the periosteal covering of the bone, causing some roughening of the bone and great tension of the periosteum, which easily explained the agonizing character of the pain, since a condition was present not unlike a subperiosteal abscess, which produces such excruciating pain. The periosteal tumor in some places began to infiltrate the overlying muscle and fascia. A considerable portion of this tissue was removed; macroscopically it was perfectly characteristic of sarcoma. In fact, with the clinical history and macroscopical appearance, one could easily make a positive diagnosis of sarcoma. In spite of this the tissue removed for microscopical diagnosis did not show any characteristic tumor tissue, so that Doctor Ewing stated that he could not make a diagnosis of sarcoma. If the patient had continued to improve and made a complete recovery, there would always have been some doubt as to the diagnosis. A few weeks later another exploratory operation was performed in order to facilitate the use of bare tubes of radium. This time some of the tumor tissue was removed and examined microscopically. The histological structure was that of a typical small round-celled sarcoma. In very far advanced cases, the clinical signs, combined with the X-ray picture, may be sufficiently clear to definitely establish the diagnosis, and too much weight should not be given to a negative pathological report upon a specimen removed.

I still believe that in cases in which there is any reasonable doubt of the diagnosis, the advantages of an exploratory operation greatly outweigh the disadvantages. If the tumor is a periosteal sarcoma, it is extremely important to make the earliest possible diagnosis. It would certainly be unwise to sacrifice the limb, without a positive diagnosis, and it would be equally unwise to subject the patient to the discomforts of prolonged toxin or radium treatment, unless the diagnosis was reasonably certain. In the great majority of cases the clinical signs, confirmed by X-ray pictures, render the diagnosis practically certain. If the disease is far advanced, there will be no doubt. Even in these cases, particularly in tumors of central origin, it may be wise to make an exploratory incision, remove as much as possible of the tumor tissue and, in the central tumors, curetting to bare bone in order to facilitate the use of conservative methods, particularly the introduction of bare tubes of radium into the cavity. The histological type of tumor found may give us great help in making a prognosis.

The danger of metastases resulting from such exploratory operations is, I believe, extremely slight, and the advantage of knowing exactly the type of tumor one is dealing with, far outweighs the risk.

Giant-celled Sarcoma or "Giant-celled Tumors."—Great confusion has long existed in regard to the malignancy of the so-called giant-celled sarcoma of the long bones. Within the last few years several admirable papers have been published throwing much light upon this difficult subject, the most important of which are the contributions of Platou, of Christiania (ANNALS OF SURGERY, March, 1918), and Bloodgood (ANNALS OF SURGERY, April, 1919). Bloodgood reports 47 cases of benign giant-celled tumors (43 of the long bones) in which the ordinary features of malignancy were absent. A study of these cases has induced Doctor Bloodgood to make a repeated and even stronger plea than hitherto in favor of conservative treatment of these conditions.

My own experience, based upon a study of 250 cases of sarcoma of the long bones, would justify me in going even further than Bloodgood, and I would urge the employment of conservative methods, not only to benign giant-celled tumors, osteitis fibrosa and the like, but to actual sarcomas of the long bones, both of central and periosteal origin.

Platou, of Christiania, bases his paper on a histological study of nine cases that have come under his observation, and which he has reported in full.

He takes the position that the so-called giant-celled sarcoma is not a malignant tumor at all, but is properly classed as "giant-celled tumor." Although he states that the microscopic picture, which he describes in detail, usually shows a peculiar structure which is easily recognized, he further states that it is not possible to give any decisive distinguishing features between sarcoma and giant-cell tumor. According to Platou, "if the resorption of the osseous substances can be shown to take place in connective tissue with few cells (if, in other words, fibrous marrow is found), then that fact would indicate that the bone-destroying process is not of a malignant character." He adds, "The most striking feature of the disease is the enormous giant-cells with 50 to 100 nuclei in one cell. The picture on the whole shows a varied structure with regions rich in cells and bands of connective tissue, often showing hyaline degeneration; between them every variety merging into tumor-like tissue, also bone substance in the process of formation, resorption, and once in a while islands of cartilage. The cells are mainly round or oval, their protoplasm most often clear and well defined in outline; frequently no intercellular substance can be traced.

"On the other hand, a giant-cell sarcoma under the microscope shows a more homogeneous tissue, with no such extensive spots where cells are few. The shape of the cells is more like a spindle, the intercellular substance more abundant, and besides the giant-cells we find all intervening stages down to cells with 2 to 4 nuclei—a thing rarely seen in the case of

giant-cell tumor. We have been told that if giant-cells are seen in clusters this fact would be an indication that the tumor tissue is part of osteitis fibrosa, whereas in the case of sarcoma the giant-cells would be more evenly distributed throughout the tissue."

Platou's series of 9 cases further confirms the opinion long held by Bloodgood and others that a certain number of giant-cell tumors of the long bones, particularly of the tibia, are benign in character, and while easily cured by conservative operation, the limb should seldom, if ever, be subjected to amputation.

Platou after a careful study of his own cases and those reported in the literature has reached the following conclusions:

"It is deplorable that microscopical examination sometimes permits only a probable diagnosis. The interpretation of the preparation in question will always depend on a personal opinion. There has not yet been discovered any test whereby the diagnosis may become absolutely certain either way when the cases are doubtful.

"The operator, therefore, must take upon himself the responsibility of deciding whether to take the usual consequence of a diagnosis of sarcoma, when he is aware of the fact that the original disease may be osteitis fibrosa, or whether the clinical facts of the case justify a conservative treatment—nay, even demand it."

This is practically the position which I personally have held for a long time, although I believe that resection and transplantation of bone are seldom necessary.

If we could always be sure we were dealing with a benign giant-celled tumor of the long bone, such as Bloodgood describes, simple curetting, which he advocates, or in more advanced cases, resection, would suffice. But we must admit that in many instances it is difficult to determine whether a case in question is a giant-celled tumor of benign type, or an actual sarcoma with malignant features. In my own list of giant-celled sarcomas of the long bones, 40 in number, the diagnosis of giant-celled sarcoma was made by a number of leading pathologists. Yet the fact that out of these 40 cases 8 died of metastases proves that in certain cases, at least, the tumor was of a very different type from that described by Bloodgood and Platou.

Perhaps in the light of more recent study of these tumors it may be possible to differentiate, in a larger number of cases, the malignant giant-celled tumors from the benign. But at the present time, we must admit there are few that are able to make the distinction positively.

That the myelogenous or mixed giant-celled sarcomas, particularly of the lower end of the femur, are, for the most part, true malignant tumors, is well brought out by the statistics of the Bruns Clinic, reported by Kocher in the *Beitr. f. klin. Chir.*, 1906, Bd. 50, Hft. 1, p. 118. In 33 consecutive cases of central myelogenous sarcoma, 4 were too far advanced for amputation or the patient refused it (it is assumed that these ended fatally); of

11 cases in which amputation was performed, 1 died of the operation, 8 died of metastases, and only 2 were known to have been well beyond the three-year period. As no microscopic sections were published it is impossible to state how many were of the "giant-celled type" described by Bloodgood and Platou. If none were of this type it only confirms my own opinion that the benign giant-celled tumor of the femur is comparatively rare, especially when accompanied by the clinical signs of malignancy, rapid growth and extensive invasion of the surrounding tissues, especially the knee-joint.

My own series of cases shows that in a small number of cases of periosteal and highly malignant tumors of the long bones, the limb as well as the life of the patient can be saved by the prolonged use of the mixed toxins of erysipelas and bacillus prodigiosus, and even a larger number of cases with tumors of central origin of unmistakably malignant type, can likewise be saved.

If the tumor appears almost certainly benign, curetting alone will probably prove sufficient to effect a cure, but my own experience, covering 250 cases of sarcoma of the long bones, with 40 of the giant-celled type, shows that this type of tumor of the long bones is comparatively rare. I should hesitate to place complete reliance on the microscopical examination alone, unless fully supported by the clinical history and the X-ray pictures. Bloodgood's report of 43 cases of benign giant-celled tumors of the long bones, gives one, I think, a mistaken impression of the relative frequency of the condition—an impression which might be corrected by remembering that Bloodgood's interest in this subject dates back many years and his frequent reports of cases have influenced surgeons all over the country, to send him special cases, resulting in his being able to report a personal observation of 43 cases of what may still be regarded as a comparatively rare type of tumor.

In dealing with periosteal tumors we have an entirely different proposition. Here there is no longer any doubt about the malignancy of the tumor, and all agree that even the most radical operation rarely saves the life of the patient. The hopelessness of the condition warrants us in trying almost any method of treatment that offers the slightest prospect of saving the limb, and this very hopelessness justifies us, I believe, in making an exploratory operation in order to definitely establish the diagnosis at the earliest moment. The microscopical diagnosis of periosteal sarcoma is, in most cases, much less difficult than in the tumors of central origin, but in certain rare cases one also encounters similar difficulties. In a few cases it may be entirely impossible to make a positive diagnosis (histologically), yet the clinical history and physical signs leave little doubt that we are dealing with a periosteal sarcoma. Formerly I advised amputation in these advanced periosteal cases, until I found that in a number of cases in which the patients absolutely refused amputation I was able to save the limb as well as the life of the patient by the use of

the mixed toxins. In one of these cases recovery took place after metastases had developed.

The result in these cases, I believe, justifies us in treating even periosteal sarcomas by conservative methods. The question naturally arises: should we limit the treatment to the mixed toxins or to radium alone, or a combination of both. We know that the toxins, without any other agents, have cured the disease, saved the limb, and the patients have remained well for many years afterward. This is true of every type of sarcoma, both periosteal and central. As far as I know, few cases have been cured by radium alone. The only case reported in which the patient remained well five years, is that of Pinch of the London Radium Institute, 1918. No details of the case, however, have so far been published, nor do we know the nature of the histological structure of the tumor.

I have had under observation a case of periosteal sarcoma of the femur which failed to improve under a month's toxin treatment, and I then advised amputation followed by toxins. The patient later placed himself under the care of the late Dr. Joseph Bissell, who gave him repeated radium treatments. The tumor apparently disappeared and he remained well nearly two years, when he had a local recurrence which was not controlled with massive doses of radium. I then amputated below the trochanter, but lung metastases soon developed, and spinal metastases, causing death in a few months.

We have had two cases at the Memorial Hospital during the last year in which the tumors have apparently disappeared under the use of radium alone. One was a large tumor of the upper end of the humerus, pronounced chondroma from tissue removed at exploratory operation, but in view of the large size and rather rapid growth it was believed by Doctor Ewing to be chondrosarcoma. This tumor showed remarkable disappearance under radium treatment administered by Doctor Janeway, in the form of bare tubes introduced into the tumor substance, supplemented by massive doses of radium in the form of a pack. The sinus, however, persisted, and an examination of a recent curetting in May, 1919, showed the presence of a "degenerating chondrosarcoma." No active chondrosarcoma was found in this curetted material but only broken-down fragments of necrotic tumor tissue. The other case was a small giant-celled sarcoma of the upper end of the tibia which is still well a little less than one year. In view of these results it would seem that the interest of a patient suffering from sarcoma of the long bones may be best served by giving him the benefit of combined treatment, *i.e.*, the systemic effect of the toxins with the local action of radium. If the tumor does not show marked improvement in the course of four or five weeks under this treatment, I would advise amputation followed by the use of the toxins as a prophylactic against recurrence, that is, if the disease is not too far advanced for amputation.

Resection with or without bone implantation is, I believe, seldom indi-

cated. The cases I have reported in full, especially the tibia case with complete destruction of the upper five inches of the tibia, treated conservatively by curetting, toxins and radium, with almost complete restoration of the destroyed bone and the patient well nearly four years, shows how much Nature can do if the sarcoma has been completely controlled.

It is difficult to estimate the definite percentage of cases in which one may succeed in saving the life and limb in sarcoma of the long bones. It depends largely upon the stage of the disease at the time conservative treatment is begun; the percentage will be much higher in the cases treated at an early stage than in those treated at a later stage.

Nevertheless, my series of cases shows several cures in which the disease was so far advanced as to be entirely beyond hip-joint amputation. These cases show that few, if any, should be regarded as so desperate as not to warrant an attempt to save the limb as well as the patient's life. In a very large number of my cases the disease has been too far advanced for amputation, so that this series does not give a fair idea of the results which might have been obtained had the disease been treated at an earlier stage. However, they give some idea as to the number of recoveries that may be looked for in advanced cases. If we are able to cure a considerable number of patients with the disease too far advanced for amputation, we certainly have a right to expect a much larger number of recoveries in cases seen and treated in the early stages of the disease.

As the earlier cases have already been reported before the Southern Surgical Association, I think it may be of interest to give a brief analysis of the cases treated within the last five years. During this period I have had under treatment 60 long-bone cases, classified as follows: Femur, 32; humerus, 14; tibia, 9; fibula, 3; clavicle, 2. Of the 32 femur cases, amputation was performed in 13 cases after conservative treatment had failed (there was no mortality from operation); in 4, amputation was strongly advised but refused by the patient. Eleven of these patients are still living, 2 being recent cases still under treatment, with a reasonable prospect of saving the limb. One of the patients who refused amputation had a large central sarcoma of the lower end of the femur, which was treated with toxins and radium, with slight temporary improvement; metastases later developed in the lung and the patient lived but a few weeks. One periosteal sarcoma had toxins followed by amputation; well three years when a recurrence developed. One central sarcoma of the lower end of the femur with extensive involvement of the knee-joint, refused amputation, and recovered under the toxins alone; well five years. One extensive sarcoma of the lower end of the femur involving the knee-joint and upper end of tibia, in which amputation was refused, was treated with toxins supplemented by radium, and is well now three years, walking without support of any kind. One very large inoperable sarcoma of the upper half of the femur, quite beyond hip-joint amputation, recovered under toxins and radium and is well at present without any evidence of

the disease two years later. Two cases of periosteal sarcoma of the femur treated with radium and toxins during the last six months in the hope of saving the limb, result still doubtful. In three cases of sarcoma of the femur, amputation was performed followed by the use of the mixed toxins as a prophylactic against recurrence; two cases are still well three years later, and the third died of metastasis nearly three years after amputation.

NOTE.—Recurrence has taken place in one of these cases in October, 1919.

Following is a brief report of cases containing points of special interest:

Cases I and II have been reported in Transactions of New York Surgical Society with microphotographs of tumors in ANNALS OF SURGERY, March, 1917.

CASE I.—*Central Sarcoma of the Lower End of the Femur with Extensive Involvement of the Knee-Joint, Successfully Treated with the Mixed Toxins.* L. G., female, twenty-one years of age, was first seen in consultation with Dr. V. P. Gibney, at the Hospital for Ruptured and Crippled, in October, 1914. Family history negative, Wassermann negative; no history of antecedent trauma.

Eight months previously patient first noticed pain in the left knee, while walking up and down stairs. This gradually increased in severity and shortly after was present even while walking on level surfaces. She consulted a physician who made a diagnosis of tubercular disease and applied Buck's extension to the knee, with slight temporary relief. A little later she entered a hospital where a plaster-of-Paris splint was applied, which she wore for five weeks. No improvement was noticed; thereupon several teeth were removed, on the ground that she was suffering from osteoarthritis due to pyorrhoea. Later on she was placed upon specific treatment. In spite of these widely varied therapeutic measures, the swelling and pain increased, and the patient was unable to bear the weight of her body upon the limb. She was admitted to the Hospital for Ruptured and Crippled (Doctor Gibney's service) on October 24, 1914, at which time physical examination showed general condition good; heart and lungs normal, patient wearing a plaster splint. She had lost considerable in weight. There was marked swelling and infiltration of the whole lower end of the left thigh and anterior aspect of the left knee. The knee was completely extended, with very greatly increased abnormal lateral motion, showing destruction or extreme laxity of the tissues. There was marked infiltration of the popliteal space, and moderate atrophy of the limb.

Measurements.—Left, 15, 15½, 12; right, 14¼, 14, 12.

The X-ray showed very marked expansion of the lower extremity of the femur; cortical substance thin and apparently on the point of breaking through; structure of bone has disappeared.

In view of the extensive involvement of the knee-joint, accompanied with great tenderness and extreme mobility, after careful examination and study of the X-ray plates, I concluded that the

disease was undoubtedly a central sarcoma which had pierced the cartilage of the joint, causing joint involvement and effusion. This condition is extremely rare and I had never, up to that time, seen a case similar to it with such extensive joint involvement. Doctor Gibney and Doctor Whitman also believed the condition to be sarcoma. All of us considered it too far advanced to justify conservative treatment, and strongly urged immediate amputation. This, however, was refused by the patient and her family. On November 6, 1914, an exploratory operation was made to obtain a piece for microscopic examination. On cutting down to the periosteum, a mass was found which occupied the entire lower end of the femur, the central portion of which was greatly expanded and occupied by a tumor having the typical clinical appearance of a sarcoma. It was quite vascular and penetrated into the joint; there was considerable effusion in the joint. As much of the tumor as possible was curetted and the wound packed. Hemorrhage, which was severe, was fairly well controlled with tight packing, and the limb was put in a plaster-of-Paris splint. After microscopical examination Dr. F. M. Jeffries reported it as a "mixed-celled sarcoma."

A further examination was made by Dr. J. Ewing, who reported as follows:

The material consists of several broken portions of tumor tissue, each about 1 cm. in diameter.

On section the masses are composed of dense fibrous tissue, in many places hyaline, covered with a fringe of sarcomatous tissue of the type of giant-cell sarcoma. The giant cells are of the epulis type. There are a few trabeculae of bone which are separated by spindle tumor cells and are undergoing absorption. In several places the dense fibrous tissue is infiltrated by strands of tumor tissue in which the cells are spindle in form, with slightly hyperchromatic nuclei, but without admixture of giant-cells.

In the absence of full data regarding the anatomy of the tumor and its clinical course, it is impossible to give any positive opinion of the clinical malignancy of the case. The giant-cell areas belong in a group which generally pursues a benign course. The spindle-cell areas seem to possess greater growth capacity.

X-ray examination, November 11, 1914, showed an attempt at formation of a new joint; shaft of femur resting on the outer articular surface of the tibia. Over the inner articular, to correspond with the inner condyle, is new bone formation, making a contour of a fairly good joint; no ankylosis between femur and tibia. Lateral view shows new bone formation, anterior to the patella; appears to be some ankylosis with the patella; no evidence of metastasis.

A few days after the exploratory operation the patient was put upon the mixed toxins of erysipelas and bacillus prodigiosus, and the doses were carried up to the point of giving a severe reaction. The toxins were begun on November 11, one minim, and increased daily by $\frac{1}{2}$ minim, until December 27, when $8\frac{1}{2}$ minims (the highest dose) was reached, which produced a temperature of 104° . After this, a short interval of one week's rest was given; the toxins were

then resumed, and kept up for one year with occasional brief periods of rest, seventy-three injections in all being given.

On December 2, 1915, Doctor Gibney reported that there was no deformity; the limb was straight with little, if any, motion. Two days later, December 4, the patient was discharged from the Hospital for Ruptured and Crippled wearing a brace on the right leg.

Inasmuch as the sinus had failed to heal the patient was given an anæsthetic and through-and-through drainage was established; curettings carefully examined by Doctor Ewing failed to show any evidence of malignancy. Rubber tubes were inserted and kept in for a number of months.

Patient was readmitted to the Hospital for Ruptured and Crippled on March 7, 1916, for infection of the old sinus. Just before admission, she developed pain and slight fever. Examination revealed what was apparently an inflammatory enlargement of the knee with a boggy swelling of the popliteal region. These symptoms continued and later fluctuation developed. In March, under local anæsthesia, an incision was made in the popliteal opening and a small abscess was found which apparently communicated with the old sinuses. One of these was opened and curetted and both openings were drained. Examination of curettings again failed to show evidence of malignancy. She was shortly treated with "Dakin's fluid" and rapid healing followed. The toxin treatment was resumed for a brief period.

The patient was shown before the New York Surgical Society in November 22, 1916, and again in January, 1919. She was also presented at the meeting of the American Surgical Association on June 16, 1919, at which time she was in good health with no trace of a recurrence, over four years later. She has $2\frac{1}{2}$ inches of shortening and walks with a brace, without crutch or cane. (She is still well October 25, 1919.)

CASE II.—Extensive Sarcoma of the Upper End of the Tibia Involving the Fibula. C. M., female, seventeen years of age, was admitted to the Hospital for Ruptured and Crippled on July 22, 1915, with a history of having first noticed trouble in the upper part of the right leg, just below the knee-joint, six months prior to her admission. This consisted of a small swelling on the inner side of the upper portion of the right tibia, slight amount of pain, increasing disability, and moderate loss of weight; no enlargement of glands in the groin. At the time of her admission to the hospital she presented a symmetrical enlargement of the whole upper portion of the right leg, most marked below the patella. The limb could be flexed to about a right angle; no muscular spasm. Over the inner portion, the tumor was extremely soft on palpation, having the "feel" of semi-fluctuation.

Measurements.—Right, $11\frac{1}{2}$, 12, $12\frac{3}{4}$; left, $11\frac{1}{2}$, $11\frac{5}{8}$, $11\frac{1}{2}$, $10\frac{3}{4}$. X-ray showed a tumor involving the entire upper extremity of the tibia, the bony structure of which was practically destroyed except on the outer and upper aspect; other bones not

affected. The disease was so extensive that amputation was strongly advised, but refused by the patient. In view of the successful results obtained with the toxins in the case of sarcoma of the femur, already detailed in this paper, conservative treatment was advised in the present case, *i.e.*, curetting for a microscopical section, to be followed by toxin treatment. In this opinion Doctor Gibney concurred.

On August 2, 1915, a four-inch vertical incision was made below the knee. The tumor was curetted out, and found to involve the whole upper part of the tibia for a distance of four inches, and nearly the same length of the fibula, with the exception of the outer wall; a thin layer of cartilage which was perforated in curetting was all that was left of the upper end of the tibia. The wound was packed with gauze, and a roller bandage tightly applied and the limb put up in plaster-of-Paris before removing the tourniquet. Pathological examination was made by Dr. F. M. Jeffries (pathologist to the Hospital for Ruptured and Crippled), who reported the tumor to be "giant-celled sarcoma."

Dr. James Ewing also examined a section microscopically and reported: "Tissue composed of typical giant-cell sarcoma of epulis type and of very moderate malignancy."

A third examination was made by Dr. George Barrie, of the Post-Graduate Hospital, who pronounced it "fibrosarcoma with giant-cells." He stated it was a true sarcoma and not a benign tumor. The clinical history of rapid development and extensive involvement and recurrence after operation furnish sufficient evidence of the malignant nature of the tumor. Blood examination August 10, 1915: Red blood-cells, 4,700,000; hæmoglobin, 85 per cent.

Four days after curetting, the patient was put upon small doses of the mixed toxins of erysipelas and bacillus prodigiosus (no other treatment). The initial dose, $\frac{1}{2}$ minim, was increased daily, by $\frac{1}{2}$ minim, until a decided reaction temperature of 102° , 103° , 104° was obtained, after which four injections a week were given.

The cavity gradually filled up with healthy granulations, and a note by Dr. V. P. Gibney, dated November 15, 1915, reads: "Open sinus over inner head of tibia; no infiltration about knee. Small range of motion allowed, not fully tested. General condition excellent. On high road to recovery."

The leg and thigh were kept in a plaster splint and the sinus treated through a window in the splint. By December 1 the sinus had closed and there was no evidence of any tumor either by physical or X-ray examination. X-ray pictures were taken regularly every two weeks. Marked new formation of bone could be noticed in the upper end of the tibia, which was completely destroyed at the time of operation. The patient also gained in weight and strength. On December 27, 1915, she was shown before the Alumni Association of the Hospital for Ruptured and Crippled, at which time there was no evidence of any lesion present.

On January 9, 1916, the patient suffered from an attack of grippe and the toxin treatment was discontinued for two weeks. On January 26, the plaster cast was removed and a recurrent tumor the size of a pullet's egg was found at the upper and inner end of the right tibia, at the site of the old sinus. An X-ray picture also showed the growth. The toxin treatment was again administered and given both locally and systemically. The tumor diminished somewhat in size but did not disappear, and on March 3, 1916, a portion of the growth about the size of a hen's egg was removed by curette and the wound was packed. A microscopical examination of the mass removed was made by Doctor Ewing, who pronounced it "giant-cell sarcoma." Blood examination, March 5, 1916: Red blood-cells, 4,856,000; white blood-cells, 7800; hæmoglobin, 82 per cent.

On March 10, 100 mg. of radium emanations were applied over the site of the tumor, and allowed to remain for twenty-four hours. The toxin treatment also was resumed, the doses being increased every day up to the point of producing a temperature of 102°-103°. The soft tumor-like area slowly increased in size and by April 1 it measured 1 by $\frac{3}{4}$ inch; it was non-fluctuating. On April 8, 150 mg. of radium emanations were applied to the lower and ulcerated portion of the swelling, and kept on for seven hours, after which it was moved two inches higher over the articular surface of the tibia. On July 22, 240 mg. of radium were applied over the same site, for fourteen hours. Her local condition continued to improve, the sinus gradually healed, and the patient's general condition returned to normal. The toxins were continued during the summer with occasional intervals of rest.

On October 4, 1916, when she left the hospital, there was no sign of a tumor and she was in good physical condition. By November 22, 1916, she had gained twenty-four pounds in weight.

This patient also was shown before the New York Surgical Society on November 22, 1916, and again in January, 1919, and was presented at the meeting of the American Surgical Association on June 16, 1919, at which time she was in good health with no evidence of local recurrence or metastases. She now walks with a brace without the aid of a crutch or cane. The recent X-ray pictures show almost complete restoration of bone. (Well October 25, 1919, over four years.)

CASE III.—*Periosteal Sarcoma of the Tibia with Metastases in the Inguino-femoral Glands; Disappearance Under Toxin and Radium Treatment; Well at Present, Nearly Two Years.* Mr. S., thirty-nine years of age, was referred to me on April 27, 1917, by Dr. John H. Gibbon, of Philadelphia. Family history negative.

Personal History.—The patient's general health had been very good, and he had practically never been ill. Ten years before he was struck by an automobile and suffered a compound fracture of the right leg, four inches above the ankle. There had been no injury to the left leg as far as known. Three weeks before he was referred to Doctor Coley the patient had noticed a swelling about two inches

above the left ankle, extending upwards and involving the inner and anterior portion of the leg for a considerable distance. It was at first believed to be a periosteitis of inflammatory origin. In the latter part of April Doctor Gibbon was called in consultation and pronounced it a sarcoma. This opinion was strengthened by an X-ray examination.

Physical examination at the time of my first observation (April 27, 1917) showed a man in robust health. Examination of the left leg revealed a marked swelling occupying the lower third, apparently originating in the periosteum and extending nearly around the leg. It began about an inch above the internal malleolus and extended upwards five inches anteriorly, and $4\frac{1}{2}$ inches on the outer side of the fibula. There was marked œdema of the whole lower third of the leg extending to the ankle. The swelling, which was most prominent over the inner and anterior part, was soft, almost semi-fluctuating, and markedly tender on deep pressure; the skin was slightly discolored. $T. = 99.5^{\circ}$.

To definitely settle the diagnosis on April 27 an exploratory operation was made. A portion removed was examined microscopically by Doctor Ewing, who reported: "Section shows a tumor composed of small spindle cells consisting chiefly of nuclei. They are very numerous, with no visible stroma. The cell masses are very compact. The tumor is quite malignant in structure."

The patient was immediately put upon the mixed toxins of erysipelas and bacillus prodigiosus, which were continued four or five times a week in doses sufficient to produce a temperature of 102° – 104° .

MEASUREMENTS

April 30, 1917:

1 inch above the internal malleolus = $9\frac{5}{8}$ inches.

4 inches above the internal malleolus = $10\frac{5}{8}$ inches.

6 inches above the internal malleolus = $10\frac{3}{4}$ inches.

The tumor itself, anteriorly = $5\frac{1}{2} \times 5$ inches.

May 5, 1917:

4 inches above the internal malleolus = $10\frac{3}{8}$ inches.

6 inches above the internal malleolus = $10\frac{3}{8}$ inches.

The tumor itself = 4×3 inches.

May 11, 1917:

4 inches above the internal malleolus = $9\frac{3}{4}$ inches.

6 inches above the internal malleolus = $9\frac{3}{4}$ inches.

The tumor itself = 4×3 inches.

On May 1, 1917, the patient was treated with radium emanations 12 by 85 mc. (1020 mc.) through 2 mm. lead filter, 6 cm. distance, applied to the anterior surface of the leg for twelve hours.

On May 8, he received the following radium emanations: 660 mc., 2 mm. lead filter, 10 cm. distance, applied to the inner aspect of the leg for twelve hours, and on May 23 the same amount of radium emanations, 2 mm. lead filter, 6 cm. distance, applied to the external aspect of the leg for twelve hours.

MEASUREMENTS

May 21, 1917:

Circumference of leg across centre of scar = $9\frac{1}{4}$ inches.

May 25, 1917:

Circumference of leg across centre of scar = $9\frac{1}{4}$ inches.

Circumference of leg across upper end of scar = $9\frac{9}{16}$ inches.

Circumference of leg across lower end of scar = $9\frac{9}{16}$ inches.

On May 26, 1917, the patient returned to his home, where the toxins were continued three times a week by Dr. R. G. Gamble, his family physician, and on June 19 he was again admitted to the Memorial Hospital for further radium treatment, at which time he received 1200 mc. emanations, through 2 mm. lead filter, 10 cm. distance, applied to the internal surface of the leg for eight and one-half hours. The toxins were then continued at home during June and July, but in view of the fact that all evidence of the disease had disappeared and he was in such fine general condition it was thought safe to discontinue the treatment for four weeks during the extreme heat in August and September.

The patient returned to Doctor Coley for observation on September 15, 1917, stating that he had recently discovered a swelling in the left groin, which was increasing in size. A physical examination showed the leg to be apparently normal. The left groin was occupied by several large glands involving the femoral, inguinal, and iliac regions, the largest of which was about the size of a big hickory nut. Doctor Coley removed one of these under general anæsthesia and forwarded it to Doctor Ewing for microscopical examination, who reported: "Actively growing sarcoma. Cells large polyhedral. No pigment. Nature of origin uncertain."

RADIUM TREATMENTS

(Oct. 1, 1917).—Radium emanation pack, 600 mc. for 7 hours, 2 mm. lead filter, applied at a distance of 10 cm. to the left inguinal and femoral regions.

(Oct. 2, 1917).—Radium pack, 480 mc., lead filter for 29 hours, at a distance of 10 cm. to the same region, making a total of 18,000 mc. hours.

(Nov. 8, 1917).—Radium pack, 1400 mc. (2 mm. lead, 0.5 mm. German silver), applied at a distance of 8 cm. over the left inguinal region for $6\frac{3}{4}$ hours.

(Nov. 9, 1917).—Radium pack, 1420 mc. (2 mm. lead, 0.5 mm. German silver), applied at a distance of 8–10 cm. over the left inguinal region for 6 hours.

(Dec. 7, 1917).—Radium pack, 1800 mc. for $6\frac{2}{3}$ hours (2 mm. lead, 0.5 German silver), applied over the left inguinal region at a distance of 8–9 cm.

The toxins have been continued for nearly two years with occasional intervals of rest. The doses have been comparatively small, not sufficient to interfere with his regular occupation, and his general health has remained perfect throughout the entire time. A recent physical and X-ray examination showed apparently no trouble remaining in the tibia and no evidence of metastases in any other part of the body.

This case, I believe, illustrates the advantage of combining the

TREATMENT OF SARCOMA OF THE LONG BONES

local effect of the radium with the systemic effect of the toxins; it also shows the importance of keeping up the toxin treatment in certain cases for a considerable period. It is too early yet to say that the patient is permanently cured, yet more than two years have elapsed since the disappearance of the primary tumor, and one and one-half years since the secondary. This patient was shown before the American Surgical Association June 16, 1919, at Atlantic City.

NOTE.—The patient was shown before the Clinical Congress of Surgeons of America in New York October 23, 1919, without trace of recurrence, in two and one-half years.

CASE IV.—*Central Sarcoma of the Femur with Extensive Involvement of the Knee-joint and Upper End of Tibia. Amputation advised, but refused; recovery under conservative treatment, curetting followed by systemic toxin injections and radium treatment; well at present, three years later.* C. S., female, twenty-nine year of age; married; family history good. Referred to me November 10, 1916; first noticed swelling over the inner condyle of the right femur seven months previously; the swelling was associated with a moderate amount of pain; admitted to St. Vincent's Hospital a few weeks before I saw her. An X-ray picture was taken and the diagnosis of sarcoma made; amputation strongly advised, but refused.

Physical examination November 10, 1916, shows a tumor occupying the whole lower end of the femur, most prominent over the anterior and inner portion, apparently involving the knee-joint. The tumor is soft and semi-fluctuating over most of the area, consistence varied in different portions. On the inner side the swelling extends down to and apparently involves the upper end of the tibia; it is smooth and globular in appearance; superficial veins dilated. Measurements of tumor— $6\frac{1}{2}$ inches on the inner side; 7 inches on the anterior side; $5\frac{1}{2}$ inches on the outer. Measurement over most prominent part of the tumor, $16\frac{1}{4}$ inches, 2 inches more than on the normal side. The popliteal space is partially filled up with a new growth of bone. The patient has been unable to walk for five months, and has lost 25 pounds in weight. Clinical diagnosis: Central sarcoma of the femur with extensive involvement of the knee-joint. X-ray examination shows a tumor occupying almost the entire lower end of the femur, apparently involving the knee-joint as well. There seems hardly any of the femur left, except the lower portion of the outer condyle. Amputation was strongly advised, but the patient absolutely refused. I finally decided to make an exploratory operation and to treat the patient with large systemic doses of the toxins of erysipelas and bacillus prodigiosus, possibly supplemented by radium. Operation, November 15: A tourniquet was applied at the upper and middle third of the right thigh and an incision 4 inches long made over the inner condyle along the inner border of the patella. A tumor, soft and semi-fluctuating, about the size of an orange, was found underneath the muscular layers. It had broken entirely through the periosteum, and while not actually infiltrating, had pushed to one side and outward the muscles and fascia.

By means of a curette and gauze sponges a large mass of soft grumous material of grayish-red color, macroscopically typical of sarcoma, was removed. The semilunar cartilages had been apparently entirely destroyed. The upper portion of the tibia for a distance of about 2 inches was almost completely destroyed and the whole joint was disorganized and occupied by a tumor which extended nearly through the outer condyle of the femur. The fibula was apparently not involved. Only a small shell of the outer side of the femur prevented spontaneous fracture. The tumor was finally curetted down to hard bone on the outer side and to the muscle and fascia overlying the popliteal vessels below, and to the upper end of the tibia until bare bone was reached. A cavity fully the size of an orange remained, which was packed tightly with gauze to prevent hemorrhage, and the limb put in a plaster splint. A pathological examination was made by Dr. James Ewing, who reported as follows: "The tumor has the general features of a giant-celled medullary sarcoma. Several areas are unusually cellular, which indicates a guarded prognosis." In a later report made on basis of examination of further sections, he states: "While the tumor shows certain areas of typical giant-cells, there are other areas in which the giant-cells are comparatively few in number and bunches of spindle- and round-cells are present."

This report taken in conjunction with the clinical history of the case, the very rapid growth of the tumor, perforation of the periosteum, complete destruction of the knee-joint and involvement of the upper end of the tibia, leave little doubt in my own mind that the tumor was a sarcoma of marked malignancy and could not be regarded as a giant-celled growth of benign character.

The packing was not completely removed until the end of a week, and the large cavity was kept clean by the use of Dakin's solution. Three days after the operation the patient was put upon systemic doses of the mixed toxins, the injections being made into the buttocks; the initial dose was $\frac{1}{2}$ m., and this was increased by $\frac{1}{2}$ m. daily up to the point of obtaining marked reactions. The highest dose was 14 minims. The patient was not very susceptible, and severe reactions did not occur until very large doses (10-12 m.) were reached. The large cavity gradually filled up with apparently normal granulation tissue. At the end of about two months the wound had practically closed without the slightest infection. Frequent X-ray pictures taken showed steadily increasing reproduction of bone at the site of the tumor.

The patient was shown before a conference at the Memorial Hospital on January 24, 1917, with the sinus healed, and able to get about on crutches. Just before the sinus had entirely closed, the toxin treatment was supplemented by the introduction of steel needles containing 100 mc. of radium, through the sinus at the bottom of the cavity; the needles were allowed to remain in place for three hours on three occasions. Later a radium pack treatment was given externally.

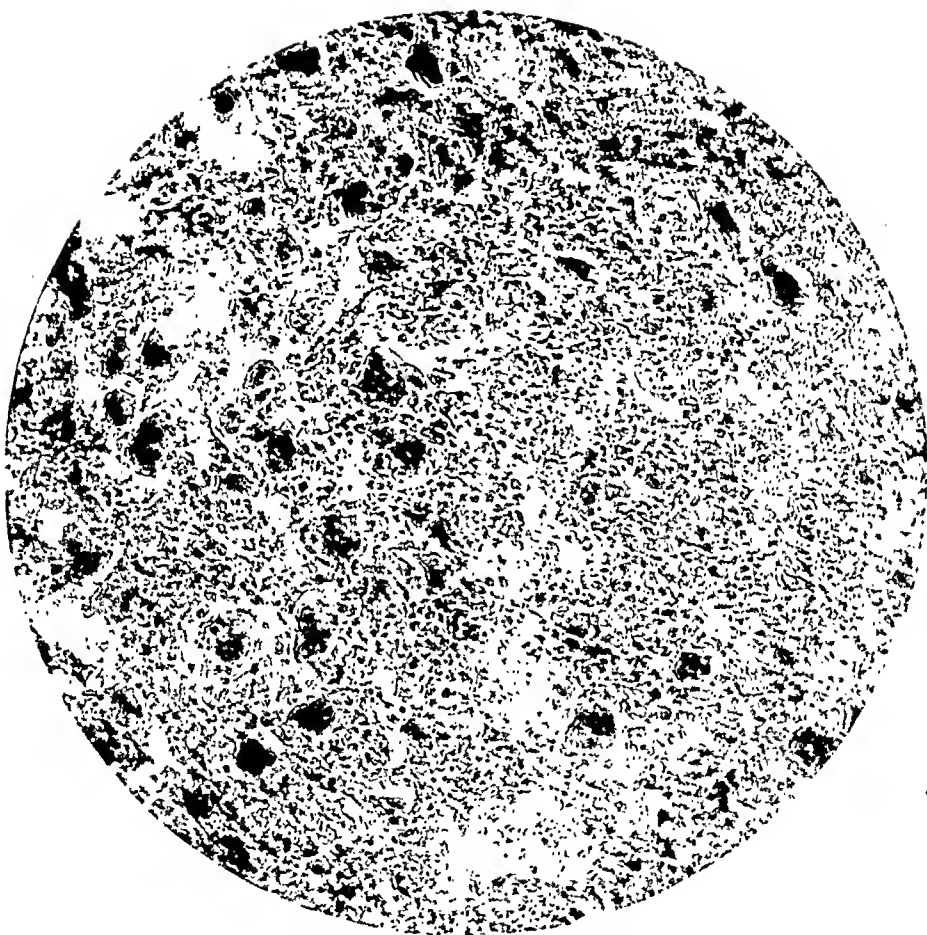


FIG. 1.—Giant-cell sarcoma of the femur, epulis type, recovering under simple curetting. Amputation advised and refused. Well in two years. Example of typical giant-celled tumor of low degree of malignancy.

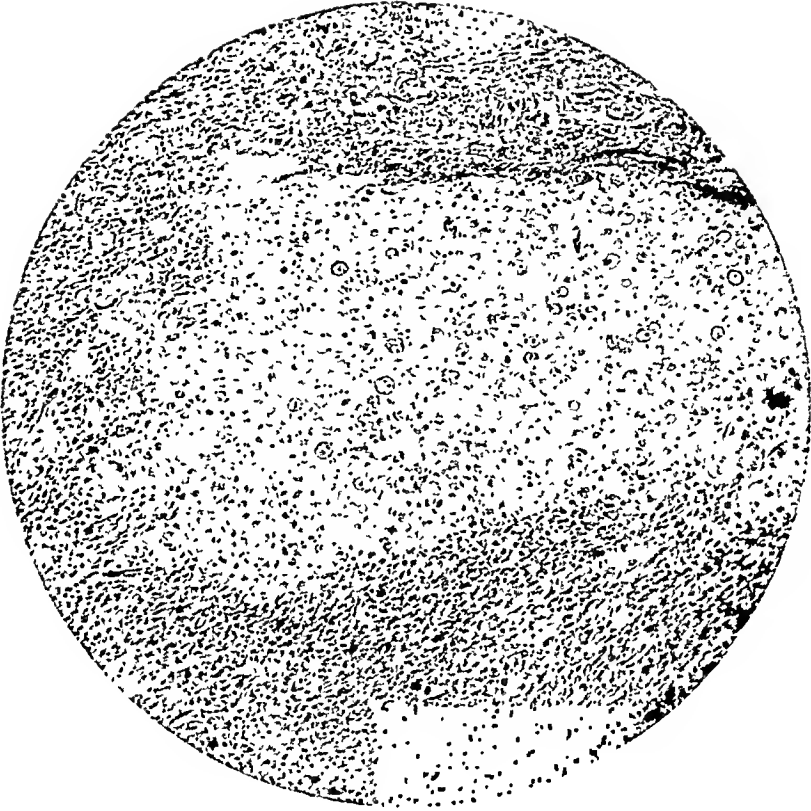


FIG. 2.—Spindle-, round-, and giant-cell chondrosarcoma. Death from metastasis in lung three years after amputation.

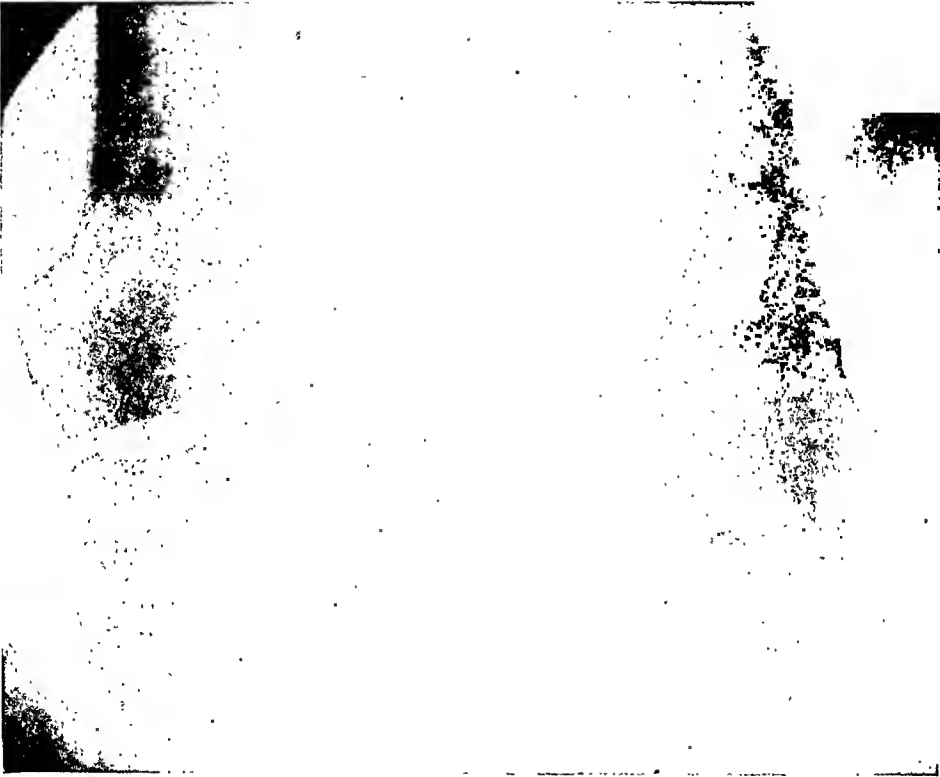


FIG. 3.—(Case I.) Central sarcoma of femur before treatment, involving knee-joint and upper end of tibia. Treated by eurtcting, toxins and radium. Complete recovery—well and walking with scarcely any limp three years later.



FIG. 4.—(Case I.) Sarcoma of lower end of femur with extensive involvement of knee-joint. Amputation advised and refused. Recovered under systemic treatment with mixed toxins alone. Patient is walking without crutch or cane at present (four years and eight months). This photo, showing extensive growth of new bone, was taken four years and eight months after beginning of treatment. Patient still wears a brace.



FIG. 5.—(Case II.) Sarcoma of tibia three years and ten months after toxin and radium treatment, showing reformation of upper five inches of tibia without bone grafting and after complete destruction by sarcoma. Treated by toxins and curetting, August, 1915, after amputation had been strongly advised by other surgeons. Patient well, in four months. Then sarcoma recurred and grew rapidly. Second curetting. Rapid recurrence. Disappeared under toxins and radium. Well October 26, 1919, more than four years. This picture taken three years and ten months after treatment. For photographs and microphotographs taken before treatment see ANNALS OF SURGERY, March, 1917.



FIG. 6.—Same case as Fig. 5, three years and ten months after treatment.



FIG. 7.—(Case III.) Periosteal sarcoma of tibia, spindle-celled.



FIG. 8.—(Case III.) Two years later spindle-celled periosteal sarcoma of tibia Very rapid development.

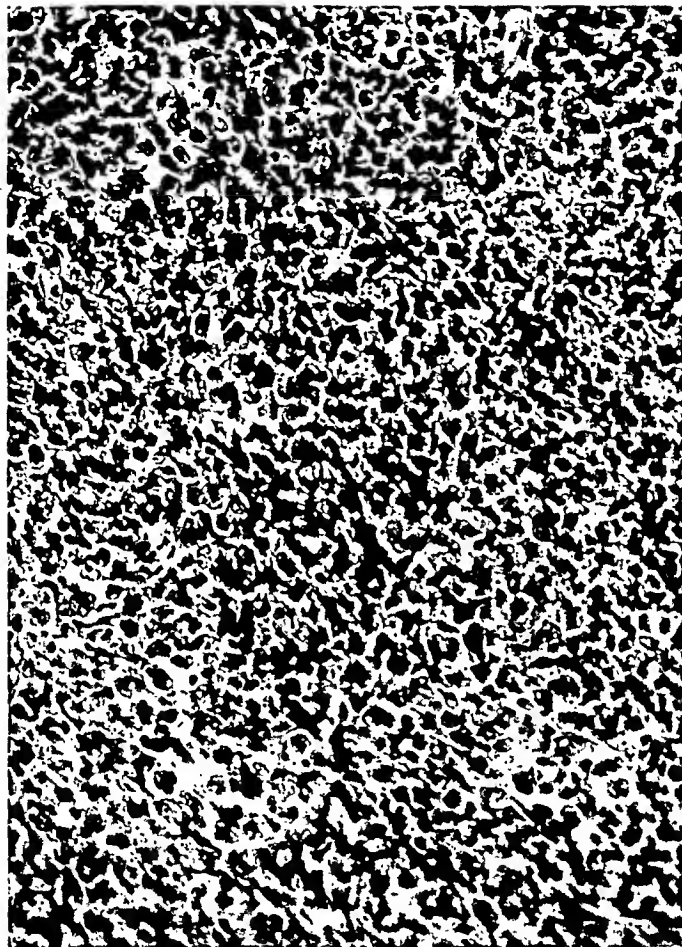


FIG. 9.—(Case III.) Periosteal sarcoma of the tibia. No giant-cells. Entire disappearance followed the use of toxins and radium, April, 1917. Recurred in glands of groin (femoral, inguinal and iliac) September, 1917. Diagnosis was confirmed by microscopic examination. Disappeared under further treatment but toxins were continued for two years. Patient well (January 16, 1919) without trace of disease. Microscopic examinations both made by Dr. Ewing. Diagnosis: Malignant spindle-celled sarcoma, no giant-cells.



FIG. 10.—(Case III.) Section from metastatic tumor removed from inguinal region. Metastatic tumor six months later in groin, which disappeared under toxin and radium treatment. Again disappearance under same treatment and patient well and free from recurrence October 26, 1919, over two years from time treatment was begun.

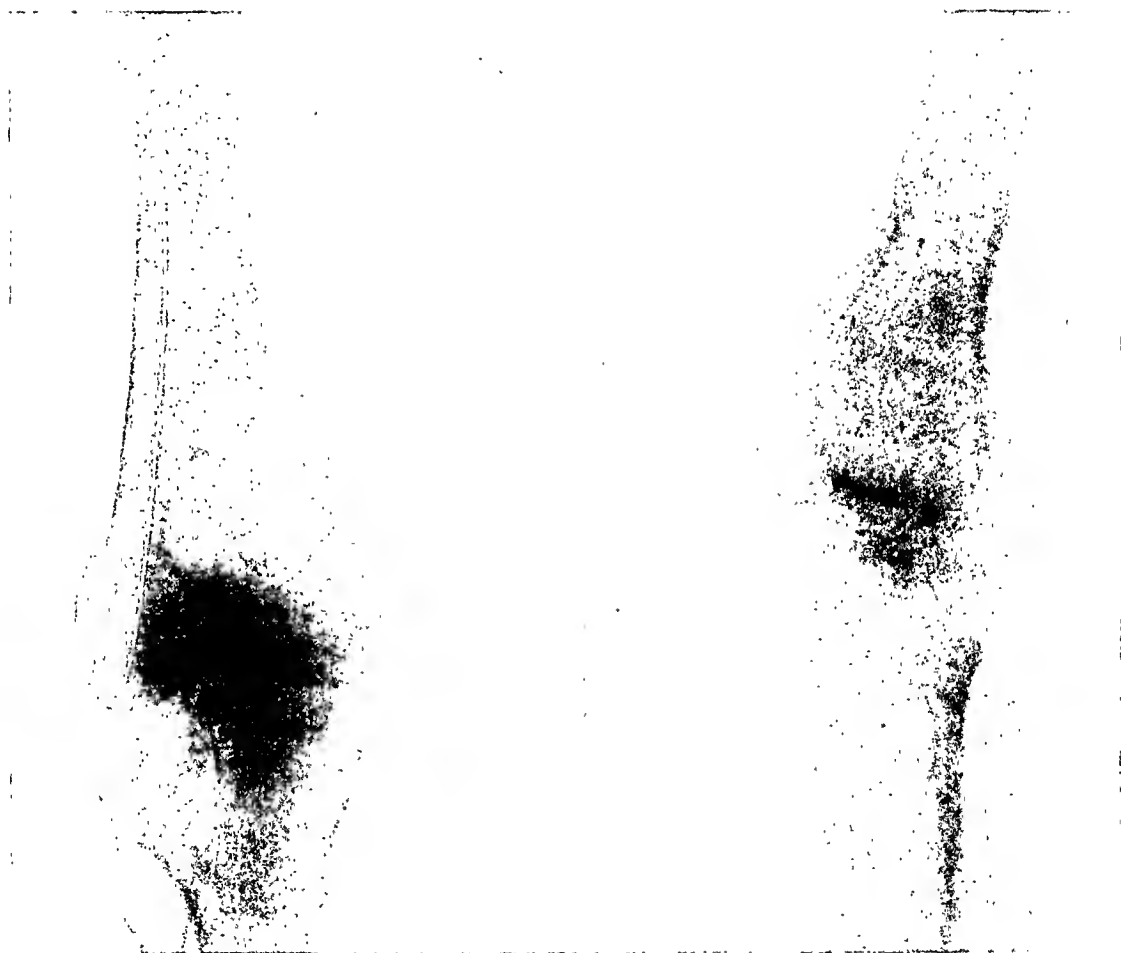


FIG. 11.—(Case IV.) Central sarcoma of femur. Giant- and spindle-celled. Rapid growth, involving the knee-joint and upper end of tibia.

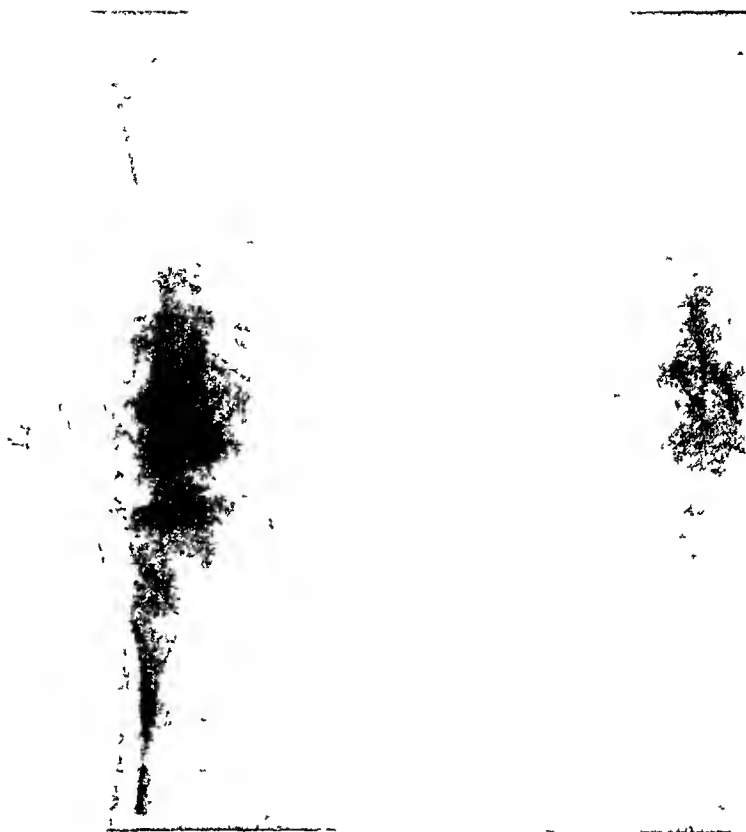


FIG. 12.—Same case as Fig. 11 two and one-half years later

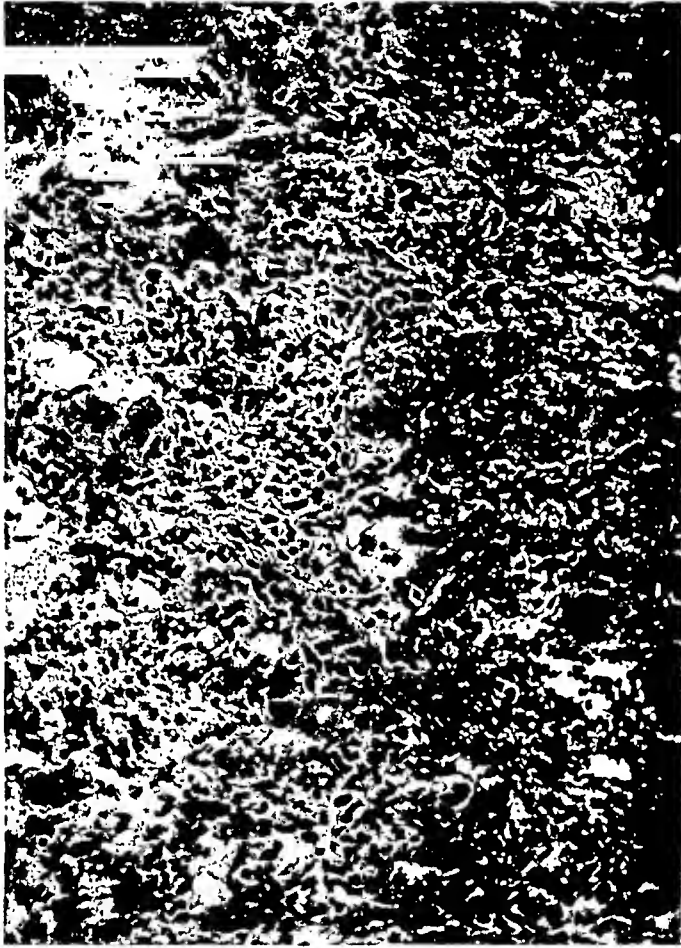


FIG. 13.—(Case V.) Spindle- and giant-celled sarcoma of femur involving knee-joint and upper end of tibia. Amputation advised by several surgeons and then at Vincent Hospital, but patient refused and was discharged. Amputation strongly urged by Dr. Coley and refused. Patient then treated by Dr. Coley by exploratory operation—curettage—followed at once by large doses of toxins. Cavity size of an orange healed by granulation. 100 mc. of radium inserted in sinus by means of steel needle and radium pack used externally. Patient well October 26, 1919, nearly three years.



FIG. 14.—(Case V) Inoperable periosteal sarcoma of femur. Disappearance under large doses of toxins and radium. Treated at Memorial Hospital, October, 1917, to July, 1918. Picture taken on admission
Entire disappearance of tumor and patient well October 26, 1919, two years



FIG. 15.—(Case V.) Inoperable periosteal sarcoma of the femur. Disappearance under large doses of toxins and radium. Treated at Memorial Hospital from October, 1917, to July, 1918. Picture taken one year after entering hospital, October, 1918.



FIG. 16.—(Case VI.) Sarcoma of femur. X-ray taken one year after beginning treatment with toxins and radium. Entire disappearance of very large sarcoma involving upper two-thirds of femur under eight months' treatment by massive doses of radium, and large doses of mixed toxins injected systematically into tumor. Patient well October 26, 1918, two years later, with five and one-half inches of shortening.



FIG. 17.—(Case VI.) Sarcoma of lower end of radius. Entire disappearance under toxin treatment alone in four months. Patient well at present, eighteen months later. See Fig. 19, taken seven months after treatment. Complete destruction lower three inches of radius. Rapid growth. Amputation advised by several surgeons.



FIG. 18.—(Case VI.) Seven months after treatment. Entire disappearance of tumor under toxin alone.
Patient now well with useful arm, eighteen months after beginning of treatment.

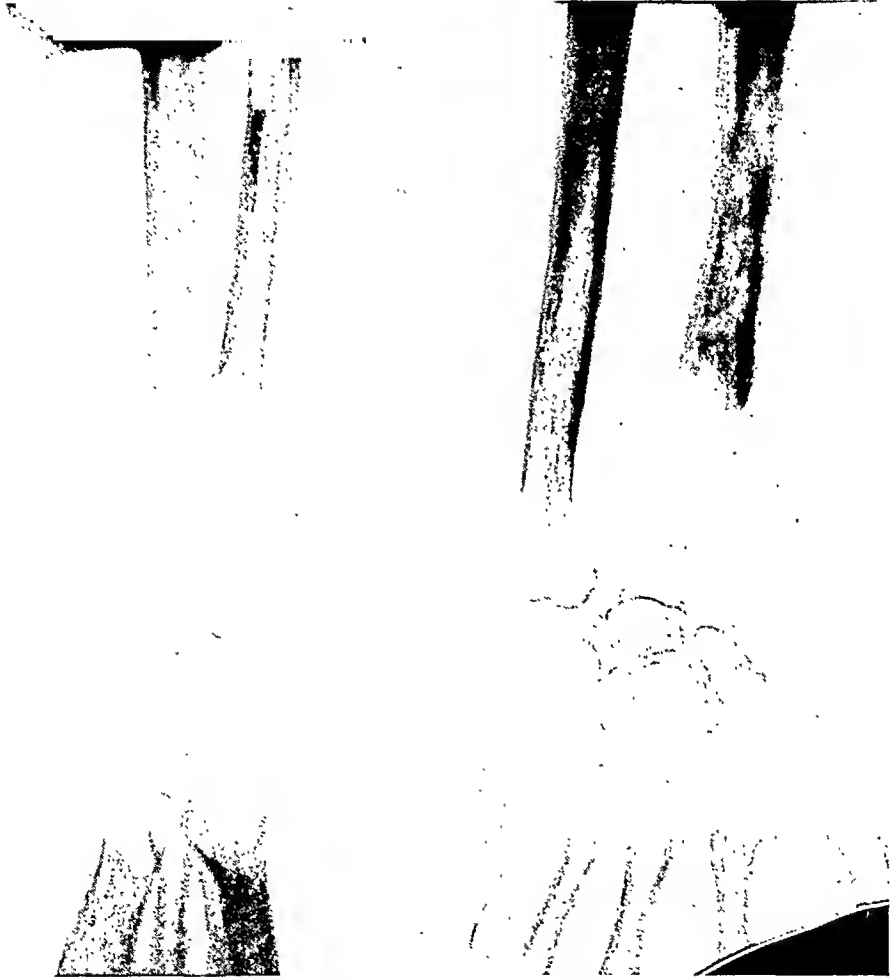


FIG. 19.—(Case VI.) Sarcoma of radius before treatment. Cured by toxins alone. Patient well October 25, 1919. Toxins injected into buttocks systematically one year and four months. No other treatment.



FIG. 20.—Same case as Fig. 19, seven months after treatment. Splint removed, and patient returned to work. Perfect function.

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The patient made an uninterrupted recovery. For the last two years she has been attending to her household duties without the use of crutch or cane. She was shown at a clinic given for the Clinical Congress of Surgeons of North America, October 23, 1919, three years after treatment, and walked with only a slight limp and was apparently in normal health. The X-ray picture shows that the original tumor area has been almost entirely replaced by new bone, and the limb is apparently as strong as it ever was. X-ray picture of the chest shows no evidence of metastases.

CASE V.—Very Large Inoperable Sarcoma of the Upper Portion of the Femur, Following a Recent Fracture; Disappearance Under Combined Toxins and Radium Treatment. Reunion of Pathological Fracture; Well at Present, Two Years After Beginning of Treatment. R. H., male, thirty-six years of age, had been entirely well up to January, 1917, when he slipped on the ice, causing a fracture of the left femur, a little below the trochanter. He was taken to St. Vincent's Hospital in Bridgeport, Conn., where he was treated by Dr. Geo. W. Hawley. X-ray pictures had been taken at the time, but owing to Doctor Hawley's having been engaged in military service, I have been unable to see the pictures as yet. The hospital report, however, mentions nothing more than an oblique fracture below the trochanter. If there had been a pathologic fracture due to a tumor already present, it probably would have been discovered at the time of the first X-ray picture. The patient did well for nine weeks, at the end of which time a swelling appeared at the site of the fracture, and steadily increased in size.

NOTE.—I have later been over the case personally with Colonel Hawley, and he states there was no evidence of tumor in the first X-ray pictures at the time of the fracture.

He remained at St. Vincent's Hospital for twenty-seven weeks. The tumor steadily increased in size, and on October 3 the patient was sent to the German Hospital, New York City, where he came under the care of Dr. Herman Fischer. On October 20 Doctor Fischer referred the patient as an inoperable sarcoma of femur to Doctor Coley's service at the Memorial Hospital. He was examined at the clinical conference of the hospital staff, and both Doctor Downes and Doctor Coley regarded the case as entirely beyond hip-joint amputation. At this time the middle and upper portion of the left thigh measured 68 cm., and the right thigh 51 cm., and there was a complete pathologic fracture at the upper and middle third of femur. Longitudinally the tumor extended for a distance of 17 cm. The mixed toxins were begun on October 30, and continued three or four times a week, alternating the systemic with local injections, and producing severe reactions. On November 5 and 6 he was treated with very large doses of radium, by means of a pack, applied at 10 cm. distance, and remaining for a total of sixty-one hours (total dose, 40,000 mc. hours). An X-ray picture taken at the time of his admission to the Memorial Hospital showed complete destruction of the bone, involving the neck of the trochanter and

upper five inches of the shaft. An X-ray picture of the chest showed "chronic diffuse bronchitis, both apices (cloudy plates) suggestive of tuberculosis—probably metastases from the tumor in the femur." By December 10 there had been a decrease of 4 cm. in the circumference of the thigh. The radium was again applied on December 25, 1917. Examination on April 8, 1918, showed a still further decrease in the circumference of the thigh. The toxins were kept up without further radium treatment. On June 23 the patient was sent home to Bridgeport, Connecticut, to remain there during the hot weather and return in the fall. At that time his general health was good; the tumor had decreased in circumference from 68 to 60 cm., with a corresponding decrease in the vertical dimension; there was still marked mobility at the site of the fracture. The leg was put in a Thomas splint. He received no treatment during the summer.

On October 8, 1918, the patient was readmitted to the hospital, at which time his general health was good, and clinical examination showed apparently complete disappearance of the tumor. The length of the left leg was 33 inches, and the right, $38\frac{1}{4}$ inches, showing a shortening of $5\frac{1}{4}$ inches. The circumference 5 inches below the trochanter, left side, was 21 inches, and the right, $23\frac{3}{4}$ inches. Circumference 5 inches above upper border of patella, left side, $19\frac{1}{2}$ inches; right, 20 inches. The patient had had no treatment since leaving the hospital in June. X-ray pictures taken at the time of his readmission showed apparently no tumor tissue left. The proximal portion of the femur at the site of the pathologic fracture had been drawn upwards to the region of the trochanter, and there was an attempt at union due to formation of new bone. X-ray examination of the chest was negative.

At the present time the patient is still wearing the Thomas splint adjusted by Doctor Gibney. This patient was kept under frequent observation during the fall and winter of 1918-1919, and was shown before the American Surgical Association June 6, 1918. He is still wearing a Thomas splint, but the pathologic fracture has united and is sufficiently firm to permit him to raise his leg without support. Recent X-ray photographs show no evidence of tumor and his general health is quite normal.

NOTE.—He was also shown at the Clinical Congress of Surgeons in New York October 23, 1919, two years after treatment.

CASE VI.—*Central Sarcoma of the Radius; Clinical and X-ray Diagnosis; Inoperable; Entire Disappearance Without Sacrifice of the Arm, Under Toxin Treatment Alone.* L. D. G., male, twenty-nine years, was referred to me by Dr. V. P. Gibney on April 25, 1918, with the following history:

Eight years ago had sprain of the wrist, but apparently completely recovered. In November, 1917, or five months prior to my first observation, he noticed sharp pain like the prick of a needle; two months later loss of power in hand; at the same time he noticed an enlargement of the lower portion of the left wrist, which enlargement increased rapidly. Physical examination showed enlargement of the

lower portion of the left forearm, extending down to the wrist. The tumor was apparently primary in the radius, involving the lower three inches. The whole wrist was markedly enlarged, the circumference being $2\frac{1}{2}$ inches greater than on the normal side; there was apparently some thickening of the ulna as well. There was a pathologic fracture of the radius and almost complete fracture of the ulna as well. The skin was normal, not adherent; the tumor was soft, semi-fluctuating in consistency. The clinical diagnosis of sarcoma was made and confirmed by X-ray examination. The X-ray picture showed complete destruction of the radius over 2 inches; the tumor had apparently broken through the outer shell of bone and extended outward, involving the soft parts which were pushed to one side. On the left side the tumor extended beyond the ulna, which was apparently involved. The X-ray picture did not fully show the damage to the ulna, but the clinical examination showed almost complete pathologic fracture. Amputation had been advised and the patient was willing to sacrifice the arm, if necessary. He was admitted to the Hospital for Ruptured and Crippled on April 25, 1918, and put upon the systemic injections of the mixed toxins of erysipelas and bacillus prodigiosus. Only one injection was made directly into the tumor, $\frac{1}{8}$ minim. This was followed by a very severe reaction, a temperature of 104° , nausea and vomiting and marked herpes of the lip. The systemic injections did not produce any marked chill or severe reaction until the dose had been increased up to 6 m.

At the time the toxins were begun the measurement over the most protuberant part of the tumor, 2 inches above the lower end of the radius, was $10\frac{1}{2}$ inches; normal side, 8 inches. I at first intended to use both radium and the toxins in the hope of saving the limb. During the first two or three weeks of toxin treatment there was very little improvement, and in the early part of June, when I was out of town for a week, Dr. J. P. Hogue came very near amputating the arm, believing that there was little or no hope of saving it by conservative treatment. The patient was quite willing to submit to the operation.

When on my return on the 10th of June there seemed to be appreciable improvement, we decided not to use any radium and the injections were kept up systemically, every other day, in doses sufficient to produce a temperature reaction of 102° to 104° . By the end of June the swelling had nearly disappeared, and by the end of July it had entirely disappeared. The arm had been kept in splints during the early part of the treatment and later, after the tumor had disappeared, was kept in plaster-of-Paris with the hand in an abducted position, to avoid deformity while the new bone was forming. The patient left the hospital and the treatment was kept up two or three times a week until the last of January, 1919. Frequent X-ray pictures were taken of the wrist, and these showed gradual increase in new bone taking the place of the 3 inches of radius and ulna which had been completely destroyed. The patient wore a short palmar

splint for six months; the new bone which has replaced the lower end of the radius is not entirely solid yet, but I believe it will soon be completely restored and the arm will be quite as useful as ever. I feel some confidence in this prognosis for the reason that in two similar cases in which the tumor had disappeared under the toxins without other treatment—both confirmed by microscopical examination—there has been complete restoration of the function of the respective limb; one of these patients is now well more than ten years.

NOTE (October 23, 1919).—The patient has been using his arm since January, 1919, and is doing his regular work as a grocer. He has normal functions and little deformity. This patient was shown before the Clinical Congress of Surgeons October 23, 1919.

The following case shows the difficulty sometimes experienced in determining in what cases to make use of conservative treatment and in what cases to amputate:

CASE VII.—*Sarcoma of the Radius and Ulna.* C. R., male, twenty-two years of age, was referred to me on September 22, 1914, with the following history: In May, 1913, he had first noticed a slight swelling in the lower end of the right radius; this was accompanied by pain which rapidly increased in severity. In September, 1913, the lower third of the radius was resected by Dr. Howard Lilienthal. The pathologic examination of the tumor showed it to be a round-celled sarcoma with no giant-cells. Four months later there was a return of the growth in the lower end of the ulna, with spontaneous fracture. Doctor Lilienthal then referred the patient to me for the toxin treatment. Physical examination at this time showed the lower half of the forearm enlarged, the skin purple in color; there was marked protuberance of the dorsal surface of the forearm extending down to the metacarpal bone. The swelling was soft, almost fluctuating, spontaneous fracture of the ulna, egg-shell-like crackling on palpation and some tenderness. The whole lower third of the ulna has apparently become disorganized and false motion is elicited almost at any point. There is marked silver-fork deformity of the wrist, and absence of the lower end of the radius. The X-ray taken on September 23, 1914, showed sarcoma of the radius with marked osteoporosis of post-operative remnant of radius; spontaneous fracture of ulna, marked sarcomatous involvement of ulna with some attempt at periosteal proliferation. Diagnosis: Osteosarcoma. The patient went out on a pass before treatment was instituted, and failed to return until October 13, 1914. During this short interval of three weeks the tumor had increased very markedly in size; it had attained the size of a small fist, involving the lower part of the right forearm and extending up a distance of two-fifths on the ulnar side and two-fifths on the radial. He remained in the hospital until October 31, 1914, and received nine doses of the mixed toxins, ranging from $\frac{1}{6}$ to $2\frac{1}{22}$ m., the highest temperature reached being 102.5° . The injections were made locally into the tumor. No marked change was noticeable from the treatment and the patient was

referred back to Doctor Lilienthal for amputation, who operated upon him on November 2, doing a circular amputation of the humerus in its lower third. A little more than four weeks later, about the middle of December, the patient died of metastases of the lungs. A letter from Doctor Mandelbaum, who had again carefully gone over the sections in this case, states that there were found no giant-cells in either specimen. The X-ray picture in this case closely resembles the picture of the preceding case that recovered under toxins alone.

CASE VIII.—*Sarcoma of the Fibula of Marked Malignancy, Trauma.* H. D., male, twenty years, referred to me by Dr. E. J. Mitchell, of Memphis, Tennessee, on April 18, 1918. The patient had been perfectly well until ten weeks ago when, while wrestling at school, he sprained the right leg just below the knee. Two weeks later he began to have slight pain; a little later lameness developed, but no appreciable swelling, and frequent X-ray examinations showed nothing abnormal. About two weeks ago the patient was examined by Doctor Mitchell, who detected a slight swelling in the outer upper aspect of the right leg. An exploratory operation was performed by Doctor Mitchell on April 14, an incision $5\frac{1}{2}$ inches long being made over the fibula from the head downward, and a tumor was found involving the entire upper four inches of the fibula, extending into the knee-joint. The report of the microscopical examination made by Doctor Kraus, of Memphis, reads: "Endothelioma with some areas of rapid growth, round-celled type and others of slower development with central mucoid; the proliferation around pre-formed spaces is typical." The wound was drained and the patient referred to me for advice and treatment.

Physical examination at this time showed a 6-inch cicatrix beginning over the upper end of the fibula and extending to the upper and outer aspects of the knee; the exploratory wound was packed with gauze and there remained a good sized rubber drainage tube. There was very little swelling of the knee or leg and but slight tenderness over the knee, apparently little effusion of the joint. An X-ray picture taken showed extensive involvement of the upper portion of the right fibula, also evidence of involvement of the knee-joint. The patient has lost 20 pounds in weight and motion of the joint is extremely painful. The patient was put upon the mixed toxins of erysipelas and bacillus prodigiosus in doses to produce a slight chill. On the 21st of April the patient was given 6000 mc. hours of radium over the outer aspect of the tumor, and on April 25, a rubber tube containing 99 mc. of radium and four silver tubes were inserted into the sinus left from the exploratory operation covering the upper four inches of the fibula. It was left in place for six hours.

April 30: The tumor has steadily increased in size, in spite of the treatment; the effusion of the knee-joint is much more marked and there has been considerable swelling of the whole lower portion of the leg. At the site of the drainage tube in the upper portion of the wound there is beginning to appear a fungoid growth of tumor, bleeding very readily. The disease is progressing very

rapidly in spite of the treatment and immediate amputation is advised.

The toxins were given systemically for a considerable period after amputation; about four months later metastases developed in the chest. The disease ran a very rapid course, causing death six months from the time of amputation.

As regards the advantages and disadvantages of resection, I personally have never employed resection and bone-implantation in any of my cases. The end-results in the group of cases shown before the American Surgical Association—(a) extensive sarcoma of lower end of femur, well four years and eight months; (b) extensive sarcoma of upper end of tibia, well three years and ten months—show that Nature unaided is able to restore large defects in the long bones if the tumor tissue has been destroyed. Also in these cases recent X-ray pictures taken show in one case almost complete restoration of five inches of the upper end of the tibia, and in the other case a very successful attempt to reconstruct the lower end of the femur with formation of a new condyle in place of the one destroyed. If we can cure the disease and keep the limb at rest for a long period of time in plaster-of-Paris, very satisfactory results can be obtained without resection. In the cases that have come under my observation in which resection of the upper end of the humerus was performed by other men, the results have been so unsatisfactory that I hesitate to recommend this method of treatment. In one of these cases, rapid generalization of the diseases prevented an opportunity to judge of the end-results as regards the usefulness of the arm, and in the other, now six months after operation, the arm is entirely useless. I doubt if it will ever have any functional value even if the disease is cured, which at present is doubtful.

CASE IX.—*Sarcoma of the Humerus Treated by Resection.* E. D., male, twenty-eight years old, always well until September, 1917, when he received a series of vaccinations preparatory to entering the army. All the vaccinations were given in the muscles in the upper part of the right arm. A few weeks later, he began to have soreness at the site of inoculations and also loss of function of the arm. A swelling appeared and slowly increased in size until January, 1919, when he was operated upon by Doctor Hitzrot at the New York Hospital. A portion of the humerus was resected and grafts from the tibia implanted. On February 28, 1919, Doctor Hitzrot referred the patient to the Memorial Hospital for radium treatment. From that time up to the present, he has had a total of 75,000 mc. given at various occasions, varying from 9000 to 40,000 in a single application. The treatment has been given by Doctor Janeway. X-ray examination shows the absence of $3\frac{1}{2}$ inches of the right humerus. The pathological diagnosis made at the New York Hospital reads as follows: "Osteochondrosarcoma; diffuse, infiltrating growth, involving the entire bone, extending into the surrounding muscle and fascia; extensive infiltration of muscle tissue. Diagnosis: osteogenetic sarcoma."

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X-ray examination of the chest shows considerable infiltration about the right hilum, extending up into the apex; no definite glands.

July 1, 1919: The patient is still under treatment. A recent X-ray picture taken failed to show any evidence of a tumor either in the bone or soft parts, and chest examination is negative. It is too early to regard the disease as under control, but it is almost certain that the arm will be of little use, even if the patient is cured of the sarcoma.

The following case of periosteal sarcoma of the humerus is interesting from the fact that there are few recorded cases in which the patient has been well over three years. Of 54 cases of sarcoma personally observed, only 2 are known to be well beyond three years.

CASE X.—Mr. L., aged thirty-five years, was referred to me by Dr. J. M. T. Finney, of Baltimore, nine years ago. The tumor developed within two weeks after a spiral fracture of the humerus, and Doctor Finney believed that amputation offered no hope of saving the patient's life. In this case a large, rapidly growing tumor apparently disappeared under the toxin treatment alone; six months later it recurred and I performed a shoulder-joint amputation. This operation was followed by a very large recurrence in the pectoral muscle, which was only partially removed, and then prolonged toxin treatment given. The disease finally disappeared and the patient is now in good health, eight years later. A microscopical examination had been made by Doctor Bloodgood and also by Doctor Ewing; both pronounced it a highly malignant spindle- and round-celled sarcoma, no giant-cells.

This case has already been reported in full in the ANNALS OF SURGERY.

The following history illustrates the difficulties often associated with the early diagnosis of malignant tumors of the long bones. It plainly shows that in some cases it is practically impossible to make an early diagnosis, even with the aid of the X-ray and exploratory operation and microscopical section.

CASE XI.—*Spindle-celled Sarcoma of the Radius with Metastases.* W. T., aged twenty-six years, referred to me by Dr. David Felderbaum on March 26, 1919, with the following history: The patient, a college man, has always been very active in athletics; played much foot-ball, but does not remember any particular injury to the arm. Two years ago he first noticed what was believed to be rheumatic pain in the left arm, but there was absolutely no swelling. Three months later he had another severe attack of local pain, without swelling; physician could feel no tumor whatever. The first X-ray was taken in September, 1917, and showed the condition to be probably osteomyelitis. First operation in October, 1917, at the Mt. Sinai Hospital, by Dr. Alexis Moschowitz. An incision was made and the bone scraped. The tissues removed were examined by Doctor Mandlebaum, who reported "no evidence of sarcoma." A month later the

pain returned and Doctor Moschcowitz, suspecting sarcoma, again operated. At this time pathological examination of the tissues removed showed sarcoma of the small spindle-celled type. In March, 1918, a third operation was performed by Doctor Moschcowitz, who resected the upper half of the radius. The pathological examination again showed small spindle-celled sarcoma. The patient remained perfectly well until November, 1918, one and one-half years later, when he began to feel pain in the right hip. A few weeks later a soft swelling developed over the occipital protuberance; this has been increasing in size steadily up to the present time (March, 1919). He also has had severe pains in the lower side of the right thorax, accompanied by some cough, but without loss of weight. The X-ray pictures revealed a large spherical mass replacing the entire root of the left lung and small numerous masses in the lower part of the right lung, apparently mainly pleural. There is a small amount of fluid in the right chest and numerous small nodules along the root of the lung. The picture of the skull shows a cystic condition eroding the occipital bone. The patient was referred to me for radium and toxin treatment. In view of the advanced condition of the disease and the marked generalization, it was decided to try the effect of intravenous injections of the active deposit of radium, together with a radium pack over the tumors of the skull. There was considerable decrease in the size of the tumor of the skull, and slight improvement in general condition. At the present time the pain is returning and the tumors are increasing in size and generalization of lesion progressing.

LND RESULTS IN A SERIES OF 250 CASES OF SARCOMA OF THE LONG BONES OBSERVED FROM 1890 TO 1919

The serious and almost hopeless prognosis of sarcoma of the long bones from a surgical standpoint was well brought out at a symposium on Sarcoma of the Long Bones before the Royal Society of Medicine in London, November, 1912. Of a series of 61 cases observed at St. Bartholomew's Hospital during the preceding ten years, all were treated by amputation, with the following results:

Of 25 cases of periosteal sarcoma of the femur not a single patient was alive over three years later; of the myeloid type, 4 in number, only 2 survived the three-year period. Of 8 humerus cases, not a single patient reached the three-year limit. Of 2 radius cases, 1 died and 1 remained well over three years. Of 11 periosteal sarcomas of the tibia, 1 remained well over three years, and of 3 myeloid type, 1 remained well over three years. Of 61 cases of sarcoma of the long bones only 5 were well over the three-year period.

The statistics of St. Thomas's Hospital, covering the same period, show 28 periosteal cases and 17 myeloid. Of the former, not a single patient remained well over three years; and of the latter, only 5 (all of the giant-celled type) remained well for that length of time.

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It is worthy of note that conservative treatment was not employed in any one of these cases, all having been treated by amputation.

Personal Cases.—An analysis of cases personally observed from 1890 to 1919 shows:

Femur	117
Humerus	54
Tibia	40
Fibula	8
Radius	12
Ulna	7
Clavicle	11
Metacarpal	2
Total	<hr/> 251

Of 117 femur cases, 21 were alive and well over three years. Of these amputation was performed in 15 cases, preceded or followed by a course of toxin treatment, and in no less than 6 cases the limb was saved by conservative treatment. Of these 6 cases, 3 were of the periosteal type and 3 central mixed, giant- and spindle-celled.

CASE I.—A small round-celled periosteal sarcoma involving two-thirds of the shaft of the femur, with extensive metastases in the ilium. Patient was treated with X-rays in February, 1902, for the tumor of the femur. Later a very large metastatic tumor developed in the ilium and was treated with toxins alone. The disease entirely disappeared, and he remained well for ten years, and then died of carcinoma; which developed in an old X-ray burn of the thigh.

CASE II.—Extensive periosteal sarcoma of the femur, clinical and X-ray diagnosis. Amputation advised by several surgeons, but refused. Treated with toxins alone. Well eight years.

CASE III.—Extensive periosteal sarcoma of the femur, small round-celled, no giant-cells; diagnosis confirmed by microscopical examination at the State Laboratory of North Dakota. Case pronounced beyond hip-joint amputation by Dr. Wm. J. Mayo. Toxins advised and carried out by Doctor Williamson, of North Dakota. Limb saved, patient in good health ten years later.

CASE IV.—Extensive central sarcoma of the upper portion of the femur, pronounced inoperable by Dr. A. P. Gerster. Diagnosis (giant-celled sarcoma) confirmed by microscopical examination. Pathologic fracture; curetting, followed by toxins; complete recovery, reunion of bone, useful limb. Patient well when last observed eight years later.

CASE V.—Central sarcoma of the femur, with extensive involvement of the knee-joint, believed to be too far advanced for conservative treatment and amputation recommended by Doctor Gibney and myself, but refused by patient. Entire disappearance of the disease under toxins alone, and patient well at present with a useful limb four years and nine months later.

CASE VI.—Sarcoma of lower end of femur, with extensive involvement of knee-joint and upper end of tibia. Amputation advised by several surgeons, including myself, as the condition was regarded too far advanced for conservative treatment. Complete recovery under curetting and long continued toxin treatment, supplemented at the end of two months by radium in the form of a pack, and 100 mc. of radium emanations introduced into the sinus in a steel needle. Patient well and walking about with scarcely any limp three years later.

Another case might be included, inasmuch as, while there was no microscopical

examination made, the clinical and X-ray findings pointed very strongly to a periosteal sarcoma of the femur. The tumor disappeared under the toxins alone and the patient was in good health ten years later; and still another case of periosteal round-celled sarcoma of the femur successfully treated with the toxins by Doctor Runyan, of Little Rock, Ark., under my direction. An exploratory operation was made in February, 1913; microscopical examination, small round-celled osteosarcoma; complete disappearance under four months' toxin treatment; patient in good health with a useful limb four years later.

Of 40 tibia cases, 8 were known to be well for a period of more than three years after operation. Of these cases amputation was performed in 4, and in 4 the limb was saved. The cases in which amputation was done are as follows:

CASE I.—Giant-celled sarcoma of tibia; amputation of the thigh; patient remained well for seven years and then died of lung metastases.

CASE II.—Central sarcoma of upper end of tibia; amputation alone; patient well ten years.

CASES III AND IV.—Both periosteal sarcoma, well over three years; amputation, followed by toxins as a prophylactic.

CASE V.—Periosteal sarcoma of tibia, well five years after amputation, died with metastasis of skull.

The 4 cases in which the limb was saved are as follows:

CASE I.—Periosteal spindle-celled sarcoma of tibia; entire disappearance under toxins; patient well at present, twenty years.

CASE II.—Central sarcoma of upper end of tibia; mixed-celled (round-, spindle- and giant-celled); disappearance under toxins; patient well eight years.

CASE III.—Mixed-celled sarcoma (spindle and giant cells) of upper end of tibia; twice recurrent; disappearance under toxins and radium; patient well three years later.

CASE IV.—Sarcoma of lower end of tibia. Giant-celled and spindle-celled. Three times recurrent. Disappeared under toxins and X-ray, 1905. Well at present, fourteen years.

Sarcoma of the humerus has long been regarded as the most malignant of all types of tumors of the long bones, and my own series of cases supports this view. Of 53 cases of sarcoma of the humerus, only 2 survived the three-year period, and both of these cases can reasonably be regarded as cures. In the other cases the patients have all died with the exception of 2, who are under treatment at present with only a moderate chance of getting control of the disease. In the 2 successful cases, 1 was a sarcoma of the upper end of the humerus, involving the portion of capsule; exploratory operation done by Dr. J. Bapst Blake. The disease was found to be quite inoperable, too far advanced for shoulder-joint amputation. The toxin treatment was carried out under my direction. The tumor entirely disappeared and the woman completely regained the use of her arm, and remained well for twelve years, when she died from some independent trouble. The diagnosis was round-celled sarcoma.

NOTE.—Doctor Bloodgood says he has never seen a giant-celled tumor of the humerus.

CASE II.—A very malignant periosteal, round- and spindle-celled sarcoma, no giant-cells, starting in the middle of the humerus, following a recent fracture. The tumor

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apparently disappeared under toxins alone; pathologic fracture reunited; recurrence in the head of the humerus six months later; amputation; large recurrent mass in the pectoral region; incomplete removal followed by toxins; final recovery; well eight years.

Of 12 cases of sarcoma of the radius, 4 remained well beyond the three-year period. They are as follows:

CASE I.—Large giant-celled tumor of the radius, treated by another surgeon by simple curetting; observed by myself; perfectly well eight years later.

CASE II.—Extensive sarcoma of the radius, involving the ulna; amputation, followed by toxin treatment; well ten years.

CASE III.—Giant-celled sarcoma of lower end of radius; curetting by Doctor Hartley; amputation advised but refused; complete recovery under toxins; patient well eleven years.

CASE IV.—Giant-celled sarcoma of lower end of radius; small portion removed for microscopical examination; no curetting; disappearance under toxins alone; well three years later.

CASE V.—Extensive sarcoma of lower end of radius, with involvement of the ulna. Clinical and X-ray findings permitted no doubt as to the correctness of the diagnosis; amputation advised by several surgeons but refused; complete disappearance under toxins alone in May, 1918. Patient well at present with a useful arm.

This may have been a giant-celled tumor, although the bony shell has been destroyed, and the tumor was of rapid growth.

Of the 6 ulna cases, one spindle-celled sarcoma in which amputation was done remained well for seven years and then died of abdominal metastases.

Of the 8 cases of sarcoma of the fibula, not a single patient is known to have remained well beyond the three-year period.

Of the 11 cases of sarcoma of the clavicle, a total excision was done in 3, followed by the use of the toxins. This group is as follows:

CASE I.—Sarcoma of clavicle; total excision three weeks after noticing a rapidly growing tumor, which followed immediately after an injury; toxins given; local and metastatic recurrences within three months; death shortly after; whole course of disease was less than five months.

CASE II.—Total excision of clavicle for a rapidly growing periosteal sarcoma (round-celled, no giant-celled), followed by a long period of toxin treatment; patient in good health at the present time, with perfect use of arm, nine years later.

CASE III.—Total excision of clavicle for a round-celled sarcoma, periosteal, which Dr. Maurice Richardson referred to me for toxin treatment as a prophylactic. Toxins given for six months; patient in good health nine years later.

These cases are of particular interest inasmuch as the high malignancy of sarcoma of the clavicle is well known, there being few cases of cure on record—except the Valentine Mott case, in which the diagnosis is now believed to be “chondroma” instead of “sarcoma.”

A brief summary of the cases that have remained well over the three-year period:

Patients remaining well more than three years, 35. Of these the disease recurred and proved fatal after three years in 5 cases. One tibia, seven years; 1 ulna, seven years; 1 femur, five years; 1 tibia, five years; 1 femur, five years.

WILLIAM B. COLEY

TYPE OF TUMOR IN CASES WELL OVER THREE YEARS

Periosteal

Femur	8
Clavicle	2
Radius	1
Ulna	1
Humerus	1
Tibia	1
Metatarsal	1
	—
Total	15

There were no giant-celled tumors in this series of cases. One case was pronounced a chondroma at the time of the first operation (hip-joint amputation performed by another surgeon); he remained well for five years, after which the disease recurred locally; I performed a second extensive operation, followed by a course of toxin treatment; the disease recurred again three years later, involving the pelvic bones; condition inoperable; failed to respond to large doses of radium; hopeless when last seen. This case proved to be a chondrosarcoma.

One patient with a spindle-celled sarcoma of the ulna remained well for seven years after amputation, and then developed an inoperable abdominal recurrence, causing death in less than a year. Another case, a periosteal ossifying sarcoma treated by amputation, later followed by toxins, remained well for about three years and then died of metastases.

In this series of cases the diagnosis was confirmed by microscopical examination, with the exception of one case, and in this, the rapid growth of the tumor in a young adult, combined with the very definite evidence of the X-ray picture, left little doubt as to the correctness of the diagnosis. The tumor disappeared under the toxins and the patient remained well for seven years.

In this group of periosteal tumors, amputation was performed in 9 cases, followed by toxins in 7. (For a more detailed history, see the preceding notes.)

Central

Femur	7
Tibia	5
Radius	3
Humerus	1
	—
Total	16

Cases in which the Limb was Saved.—In this series of cases it has been found possible to save the limb in 17 cases; 11 by the use of the toxins alone; 4 by a combination of toxin- and radium-treatment; 2 by curetting (the latter 2 were giant-celled sarcomas, or giant-celled tumors). Of the 17 cases in which the limb was saved, 6 were of periosteal origin and 12 of central origin. Fourteen have remained well more than three years.

AN ANALYSIS OF THE RESULTS OF SIX YEARS' FOLLOW-UP SYSTEM IN A HOSPITAL SURGICAL SERVICE*

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THIS paper is a study of the end results obtained in the First Surgical Division of the New York Hospital from February 1, 1913, to January 1, 1919. This period covers 8456 patients, 7175 operations, 385 deaths. Sixty of these deaths were on non-operative cases. The cases have been followed according to the outline given in my paper, "A Surgical Follow-Up System," in the *ANNALS OF SURGERY* of September, 1916.

Briefly, the great bulk of cases, exception only being made for minor infections, etc., are examined three months after operation by the surgeon in whose charge the patient was or who performed the operation. Patients not reporting are written to. The excellent Social Service Department of the hospital has been able to trace numerous cases and give us some information about their condition. Cases of particular interest are followed for longer periods; for instance, the direct herniæ are followed for nine months, malignant tumors indefinitely. Patients are directed at the time they leave the hospital and also when they return for examination to come back to see the attending surgeon if at any time they develop symptoms or complaints. They are particularly encouraged to come on Mondays at three o'clock, which is our Field Round day, and the entire staff is present.

The condition of the patients is indicated as follows: *Excellent* means that the patient returns presenting absolutely no symptoms of any kind whatsoever and expresses himself in perfect health and perfectly satisfied with his surgical condition. *Satisfactory* means that there are no direct symptoms referable to his surgical condition, but that the patient may have some complaint, be that as it may, *e.g.*, constipation. *Unsatisfactory* means that the patient has not been improved or that there is a definite failure to obtain the desired results.

We have reason to believe that the tabulated results are made to appear bad by the fact that a large number of patients remaining in good health and having no complaints, do not respond to requests for information or examination. A very large proportion of these patients are recent and ignorant immigrants who exhibit little gratitude for benefits received, certainly not enough to give up half a day's work to report. *Per contra*, if anything is the matter with them, they are very anxious to confront the doctor with the fact.

* Read before the New York Surgical Society, November 12, 1919.

The work has been done for the most part by myself and the two associate surgeons, Dr. B. J. Lee and Dr. J. M. Hitzrot. In the first part of 1913 it was our privilege to have the coöperation of Dr. W. A. Downes who was then associate surgeon. Dr. C. E. Farr, assistant surgeon, also has taken part in some of the work and particularly during the period of the war.

Two periods of these six years have given unsatisfactory results. The system began in 1914; but for the sake of completeness, we went back and investigated, so far as we were able, our 1913¹ work, but were unable to trace a considerable portion of these cases. From July, 1917, to the end of this period war conditions materially handicapped us.

The responsibility of keeping track of these patients and sending for them has been entirely in the hands of Mrs. H. S. Harrison, and it is largely owing to her coöperation and the fact that this responsible part of the work has been done by one person that we have been able to get data of value.

Space will not allow of very detailed comments of these cases. Some of the more important groups will be the basis of papers to be published by the staff.

Whatever merit this publication may contain is believed to be due to the complete report of the entire service for six consecutive years, as studies of this kind are rare.

The First Surgical Division of the New York Hospital is under the control of Cornell Medical College and for eight months of the year there is very active teaching.

So far as feasible, some of the major groups of cases are assigned to particular members of the staff. For purposes of convenience, a certain uniformity of technic obtains; but the staff is not limited to any one method of treatment. This policy gives the individual operator opportunities to develop his own ideas and furnishes a comparison of different methods.

In the past year we have replaced disinfection of the skin by tincture of iodine by 5 per cent. picric acid alcohol solution and are much better satisfied with the results. The asepsis obtained is fully as good, probably better, and the occasional irritation such as is produced by iodine has become a thing of the past.

Two and a half years ago it was believed that better results would be obtained by discarding the newer methods of anæsthesia and in that period of time, with very rare exceptions, general anæsthesia has been obtained entirely by drop ether on the open cone. It is interesting to note that this method (suppressing preliminary nitrous oxide) does not result in any increased use of ether for the average anæsthesia. As time goes on we shall investigate whether the suppression of nitrous oxide has had any relation to the incidence of pulmonary embolism. It is my impres-

¹The Division has been conducted by the Cornell Medical College since 1913.

sion that pulmonary embolism became more marked about the time that complicated methods of anæsthesia, particularly those involving the use of nitrous oxide, were introduced.

Anæsthesia for five years has been in charge of Dr. W. L. Soule and this centralization in the hands of an expert has been attended with the very best results. We have had no case in which death could be attributed directly or indirectly to the anæsthetic.

I would make a plea for general anæsthesia, versus the routine use of local anæsthesia, which is employed by a good many surgeons, if given in a safe and controllable manner, namely, ether, open cone, by a responsible expert. While local anæsthesia undoubtedly has a very definite place in a certain group of cases, it is believed it has, on the whole, little or no effect in diminishing mortality.

A certain number of deaths from pulmonary embolism, infarct and thrombosis have been accepted by the surgical profession as seemingly inevitable. Many theories have been advanced to explain their occurrence, but none seems to furnish the true explanation. In all reports one thing stands out prominently; that is, that this condition follows operations below the diaphragm. In a previous paper² I have called attention also to the average age of the patients, namely, a large proportion occurring in middle or late life. My observations also rather combated the late development of these conditions. The cases here reported were also all below the diaphragm but showed an average age of about thirty-two years, an average development of symptoms five days after operation, death about five days later. (Exception is made of case which died sixty-seven days after operation.)

Our results may be considered from the standpoint of mortality and the restoration of function or return to health of patients. Results will fall into three main groups; namely *Good* (Group I), that is, as satisfactory as at present it is possible to expect; *Average* results (Group II), that is, no better or no worse than what we may commonly expect; and sufficiently *Bad* (Group III) to cause us disquiet and to seek for improvement of results.

Leaving aside the smaller groups for important subjects we have under Group I as follows:

GROUP I

MALFORMATIONS.³—These give good results, particularly in undescended testicle. The deaths were from extreme causes, such as spina bifida.

CIRCULATORY SYSTEM.—Forty-four operations for varicose veins⁴ with only two unsatisfactory results.

DIGESTIVE SYSTEM.—*Acute appendicitis*, 782 operations; 34 deaths (4.3 per cent.) can, I think, be classified as good in view of the class of cases admitted. A very large proportion are long delayed cases as our unfor-

² Pulmonary Embolism Following Operation, Medical Record, January 9, 1909.

³ The Bellevue Nomenclature is employed in all tabulations.

⁴ This group will be the subject of a special paper.

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fortunate patients are of a class that does not seek early advice and does not always receive prompt attention, necessitating, necessarily, severer operations and greater risks. We are under the impression to-day that if anything, the delay in sending in cases is increasing. Only five cases of this group are noted as coming back with conditions marked unsatisfactory; in marked contrast with the large number of cases of chronic appendicitis presenting subsequent complaints.

SUMMARY OF DEATHS FROM ACUTE APPENDICITIS

Number of deaths	36
Males, 18, females, 18	
Number of operations	34

Ages

1-10 years	5
10-15 years	6
15-20 years	3
20-30 years	8
40-50 years	6
50-60 years	6
60-70 years	2

Time Elapsing Between Onset of Attack and Operation

1 day	3
2 days	12
3 days	3
4 days	3
5 days	5
6 days	2
8 days	1
2 weeks	2

One case too ill to give a history. Another ill four weeks. No definite history of acute attack.

All cases save one required drainage. All were complicated by peritonitis. Further complications were:

Pneumonia	2
Intestinal obstruction	4
Paralytic ileus	1
Pneumococcus infection	1
Suppurative pleurisy, necessitating second operation	2
Pulmonary infarct	3
Acute cholecystitis	1
Secondary exploration of subphrenic space for multiple abscess of liver	1
Acute cardiac dilatation	1
Nephritis	2

Tonsils, 559 operations with one death. This death was in no way connected with the operation, but the patient died eleven days after the opera-

tion of meningitis. The operation performed was usually some form of radical enucleation and the functional results were exceedingly good.

Hemorrhoids, 184 operations, no deaths. Only 3 unsatisfactory results. This result was an agreeable surprise to us, for without this definite tabulation we would not have realized how uniformly successful this operation was.

HERNIAE.—*Femoral hernia*, 53 operations, 1 death. No recurrences. Unsatisfactory cases are those showing same pain as before operation, but no recurrence.

Femoral hernia, strangulated, 11 operations, 1 death, gave uniformly good after results.

Inguinal hernia. Of 849 operations, 168 were for bilateral hernia. Total number of operations, therefore, 933. Of the 65 cases of bilateral hernia operated on before 1916, 61 were operated on at one sitting, two at two sittings. From 1916 to 1919 of 103 bilateral herniæ, 96 were operated on at one sitting, 7 at two sittings. Of these 103 cases, 15 were direct, 68 indirect, 20 both direct and indirect. Since 1916 there have been 305 cases of hernia on the right side (including bilateral hernia). Of this number 142 have had their appendix removed.

There were two deaths; in one case from pulmonary embolism after a long illness. In this case the appendix had been removed with great difficulty. The second was an elderly man, a poor risk, who died from cardiac insufficiency and paralytic ileus. So far as mortality is concerned we believe our results are good, as owing to the greater demands for operation to-day the average age is much higher than it was some years ago. For some years we had made a practice of removing the appendix on the right side in a rather haphazard fashion, but to-day we make it a routine providing the conditions allow of a perfectly safe and easy removal, as we believe no risks should be taken of unduly traumatizing the intestine. It is interesting to note that three patients in whom the appendix was sought for and the search abandoned for the above reasons, subsequently returned to us for an operation for acute appendicitis. Possibly in cases where we cannot easily draw down the appendix and cæcum, there may be a chronic appendicitis which calls for operation. It has been interesting to note with what frequency the appendices removed as routine have shown pathological lesions, concretions, etc. In one case the appendix was full of pus.

As regards recurrences ⁵ we have definite knowledge of only 20 but believe that it must be higher. We believe that the direct herniæ are more prone to recur and require special technic. We believe that we present here a higher percentage of operations for direct herniæ than is commonly reported, and attribute the fact to our methods of demonstrating the presence of direct hernial sacs which are often overlooked unless care is taken in searching for them. In fact, we have come to regard this careful extirpation of the entire direct

⁵ This group will be the subject of a special paper.

sac as the most important feature in obtaining a radical cure in addition to the special technic of replacing the deficient conjoined tendon, either by transplantation of the rectus, or, in addition, suturing the cut edge of the rectus sheath to Poupart's ligament.

INFECTIVE DISEASES.—*Tetanus*, 3 cases, all recovered. All treated by intraspinal injections of antitoxin in addition to other treatment.⁶

Tuberculosis of kidney, 15 operations without mortality. One subsequently died at home; in two the end results are not known. In the others the improvement in health and the disappearance of symptoms were for the most part very marked and gratifying.

REPRODUCTIVE ORGANS (FEMALE).—*Extra-uterine gestation*, 51 operations, 2 deaths. Many of these are ambulance cases, desperately ill. It is, therefore, fair to consider the mortality, 4 per cent., very good.

Chronic salpingitis, 211 operations, 5 deaths, represent in many cases very severe conditions, long neglected cases, and huge suppurating tubes. Our experience has taught us that so-called conservative measures, *i.e.*, saving a doubtful second tube or partial resection of a tube, are unsatisfactory; in fact, they generally leave the patient in a bad condition and more usually necessitate a second operation. Bilateral cases are best treated by a panhysterectomy, for, as a general rule, leaving a boggy incurably diseased uterus is poor surgery.

REPRODUCTIVE ORGANS (MALE).—*Hydrocele*, 62 operations; *varicocele*, 78 operations, gave surprisingly good results. The operation usually employed for varicocele was the high excision of veins; for hydrocele, radical excision, chiefly by von Bergmann's method.

TUMORS (BENIGN).—*Fibromyoma of uterus* gives a small mortality and very satisfactory after results.

Fibro-adenoma of breast. These operations, if done properly, with the Thomas special submammary incision, give excellent results, especially from the cosmetic standpoint. In only two of these patients are recurrences noted and probably from insufficient excision. I would like to call attention to the fact that in the twenty-five years of my hospital surgery I have performed a goodly number of operations for benign conditions of the breast which I believe have acted as a prophylaxis against carcinoma. I have never yet had one of these patients return to me with carcinoma of the breast or have I ever heard of such a condition developing in any of my patients.

URINARY ORGANS.—*Nephrolithiasis and calculus in ureter*, 52 cases, 30 operations, 2 deaths which were exaggerated conditions, requiring a nephrectomy in the presence of a marked pyonephrosis. It will be noted that operations for displaced kidney (nephroptosis) were very infrequent as we believe they should be.

Abscess of kidney and perinephritic abscess, 28 operations, 2 deaths. Results excellent, only two cases being reported unsatisfactory.

⁶ See article, "Comparative Value of the Methods of Treating Tetanus," in the American Journal of the Medical Sciences, December, 1916.

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

DUCTLESS GLANDS AND SPLEEN.—*Diseases of the spleen*⁷ (including *ecchinococcus cyst*), 12 cases, 10 operations, 1 death. The fatal case was one of splenomyelogenous leukæmia in which nothing further than an exploration was possible.

Of the splenectomies, 1 Banti's disease, 1 syphilitic enlargement, 1 von Jaksch's anæmia, 1 hæmolytic jaundice, 1 pernicious anæmia, and 1 *ecchinococcus cyst* have remained well, all with marked improvement.

One Banti's disease, 1 portal cirrhosis with splenomegaly (non-alcoholic), and 1 pernicious anæmia died after short improvement.

INJURIES.—*Fractures (including faulty union)*. During the period of these statistics 447 fractures were treated. There were 24 deaths (14 in the skull fractures). Two hundred and thirty-six cases reported for observation; of these 53 were excellent, 163 satisfactory, and 21 unsatisfactory. Forty-seven cases were not asked to return because the treatment received at the hospital could have no bearing on the result.

One hundred and sixty-eight operations⁸ were done with 12 deaths; 10 in fractures of the skull, 2 in fractures of the femur (shock, 1; pulmonary embolism, 1).

The operative measures used with autogenous bone grafts, 30 cases (4 failures with subsequent operations in 2 cases); heterogeneous bone graft (beef bone) in 6 cases with 1 failure; Lane plate, 28 cases with 1 infection and 2 removals; Freeman external bone clamp, 2 cases; Quenu-Matthieu apparatus, 2 cases; suture of fragments, 33 cases; wiring, 2 cases; metal screw, 1 case; nail extension, 1 case; osteotomy, 9 cases; excision of fragments, 12 cases; arthroplasty for ankylosis following fracture, 6 cases; amputation, 8 cases. The remaining 30 operations were done to correct deformities which after correction needed no fixation or for coincident soft part injury (skull fractures).

GROUP II

DIGESTIVE SYSTEM.—*Cholelithiasis and cholecystitis*, 214 cases, 179 operations, 12 deaths. Many of these cases presented the terminal stages of severe infections and numerous cases of obstructive jaundice. It is not surprising, therefore, that the mortality should be a little high. The results, on the whole, were pretty fair, but we feel that we must exert considerable efforts to improve them. As regards cholecystotomy versus cholecystectomy, as time goes on the latter operation has been more frequently performed so that it is to-day the routine operation that we perform with improvement of results. A few cases have been encountered with carcinoma of the gall-bladder developing after a cholecystotomy some time before. A cholecystectomy done at the primary operation

⁷ "The Effect of Splenectomy on the Normal Individual and in Certain Pathological Conditions," by James Morley Hitzrot, *ANNALS OF SURGERY*, May, 1918.

⁸ The large number of operations is due to the fact that a great many of these cases are those in which the original treatment outside the hospital has not been satisfactory and they have been sent to the hospital for correction.

would probably have eliminated the possibility of the carcinoma developing.

There has been no attempt to make use of the transverse incision for gall-bladder approach, as we have found in cases of common duct obstruction that the vertical incision, close to the middle line, is ample and usually gives very satisfactory exposure.

Pancreatitis. Of the 6 cases surviving operation all reported as in a satisfactory condition of health. The three deaths were very severe cases, two dying within a few hours after an exploratory operation.

DUCTLESS GLANDS AND SPLEEN.—*Exophthalmic goitre.* There were two deaths following ligation of a single artery under local anæsthesia. Both were severe cases which had grown steadily worse under prolonged medical treatment. The surviving cases showed, on the whole, fairly good results, certainly about as good as one can ever expect to get following operation.

HERNIÆ.—*Inguinal hernia, strangulated* (41 operations; 6 deaths). Of these six deaths, three cases required intestinal resection, two were complicated by pneumonia, and one case was a poor operative risk, a man seventy years of age. The ages of these cases were thirty-eight years, thirty-nine years, fifty-four years, sixty years, seventy years and seventy-two years. The two youngest patients died of pneumonia. This is a class of cases, especially in an elderly individual, where a two-stage operation has given in many cases good results. The first operation, done under local anæsthesia, is limited to overcoming the obstruction, usually very easy, or remedying the damage to the gut by an appropriate resection. The second stage for the repair of the hernia is done a few days later, usually under a general anæsthetic, when the patient has recovered from the shock and disturbance of his original condition.

Umbilical and ventral hernia. Both radical cure and operation for strangulation, 87 cases, 74 operations, 12 deaths. Seemingly this mortality is too high, but it must be remembered that a large proportion of these people are quite unsuitable for operation, many of them being stout elderly women with degeneration of the viscera and changes in the blood-vessels. Operation for radical cure was seldom done except in the face of a threatening condition or the patient's refusing to suffer the discomfort of a permanently irreducible hernia. In the strangulated conditions the operation is always prolonged and difficult and often requires intestinal resection.

INFECTIVE DISEASES.—*Tuberculosis of digestive system.* Peritoneum, 18 original cases, 3 deaths.

Report on 9 cases: 1 case died two weeks after leaving hospital.

Date of operation	Last report
June, 1918.....	May, 1919. Gained 13 pounds. No symptoms.
Apr. 9, 1917.....	May 22, 1917. Recurrence of condition. Sent to country.
June 5, 1918.....	Oct. 10, 1918. Feels much better. Gained 3 to 5 pounds. Still has abdominal sinus and free discharge.

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Date of operation	Last report
July 19, 1917.....	Nov. 4, 1918. Fat and well. Complains of pain in right lower quadrant and vague symptoms.
Nov. 22, 1914.....	Mar. 15, 1915. Working and well.
Aug. 6, 1915.....	Nov. 29, 1915. Patient has gone to Germany. In good health.
Aug. 25, 1915.....	Feb. 13, 1919. Marked improvement. Abdomen soft, no fluid. No masses felt. Gained in weight.
Oct., 1915. No operation...	Jan., 1916. Looks very bad.

Cases found under those returning for second operation: Five cases—1 death in hospital; 1 case 21 days after leaving hospital; 1 case not found. Report of other two: Operation, September 24, 1917. Note, December 31, 1917. General condition markedly improved. Still has an open granulating wound, discharging some pus. Operation for tuberculous kidney October 4, 1915. Operation for tuberculosis of peritoneum January, 1917. January 5, 1919: Absolutely all right.

REPRODUCTIVE ORGANS.—*Acute salpingitis*. On the whole, we do not favor operations in the acute stages as convalescence is rather more stormy and the risk somewhat greater. Operation has more often been resorted to when the patients failed, under observation, to show speedy signs of improvement. A certain number of cases have wisely been operated on at this stage owing to the real difficulty sometimes encountered in differentiating between acute right salpingitis and appendicitis, and we prefer to take no chances where such a doubt exists.

Prolapse, retroflexion, retroversion, lacerated cervix and relaxed pelvic floor. While the results on the whole are satisfactory, we are seeking constantly to improve our methods, especially in the very extreme cases of prolapse of the third degree. It is not our custom to operate on retroversion, simply on the anatomical finding, but to relieve definite symptoms. The repair of laceration of the cervix gave good results.

GROUP III

DIGESTIVE SYSTEM.—*Ulcer of stomach and duodenum*. The results in this class of cases were unsatisfactory as regards operative mortality, 8.5 per cent., which is rather high, although the more recent work has shown marked improvement in that direction. They are, of course, unselected cases and many of them present advanced conditions, making operative procedures complicated and difficult. As regards functional results, on the whole, they are fair. The best results have been obtained in the well-defined, duodenal ulcers, treated by gastro-enterostomy without any other operative procedure. A few cases had some form of blocking of the pylorus added to the gastro-enterostomy. On the whole, these cases did not do so well and this procedure has been abandoned by me. More recently we have had the benefits of better and more accurate ante-operative observation and diagnosis, such as fluoroscopic examination (by Dr. A. L. Holland) with resulting benefits to our results in every way.

Ulcer of stomach and duodenum, perforating. The results are two-fold: the operative mortality is too high (10 deaths out of 39 operations),

but the after-results have been very good, no case being recorded as unsatisfactory and the great bulk of patients have shown marked improvement in health. Gastro-enterostomy at the time of the original operation has only very exceptionally been performed. None of the cases here recorded has undergone it subsequently. The mortality of the perforating ulcer of the stomach is almost entirely a question of time, and the following table simply serves to demonstrate this fact. It will be noted that only one case which was operated on less than twenty-four hours after the perforation occurred died.

TIME ELAPSING BETWEEN PERFORATION AND OPERATION (Report on 39 cases of perforating ulcer of stomach and duodenum)	
1 <i>Deaths</i>	10
Forty-eight hours (2)	
Forty-six hours	
Thirty-six hours	
Twenty-four hours (3)	
Twelve hours	
One patient ill ten days.	
One too ill to give detailed history. Had apparently been ill two weeks.	
2. <i>Still living</i>	29
One and three-quarter hours	
Between 2 and 3 hours (2)	
Between 3 and 4 hours (5)	
Four hours (2)	
Five hours (6)	
Seven hours	
Eight hours (3)	
Nine and three-quarter hours	
Seventeen hours	
Twenty-four hours (4)	
Three days	
Five days	
Ten days. Patient operated on five days after admission for abdominal abscess; five days later for perforating ulcer. His illness had been of two weeks' duration. Operation for ulcer ten days after admission.	

Cirrhosis of liver, 5 operations, 3 deaths. In general our impression has been that the results from omentopexy for cirrhosis of the liver are usually bad. Most of the cases are exceedingly poor operative risks with marked renal disease who react very unfavorably to operative procedures. We believe that only a very favorable case should be considered for operation.

Chronic appendicitis,⁹ 552 operations with 3 deaths. As the number of unsatisfactory cases is quite large a very exhaustive investigation of the subject will be published by me soon. The number of unsatisfactory cases, 30 per cent., is somewhat exaggerated, as we have definite reasons for believing that in the 139 non-investigated cases we probably had the best results. We may say in general that the results were best in the

⁹ This group will be the subject of a special paper.

male, in patients with definite history of previous attacks, in cases presenting well marked pain over the site of the appendix as the principal symptoms. Also in patients whose general intelligence and knowledge of the English language allowed them to give satisfactory histories. In the thoroughly satisfactory cases the appendix is definitely noted as obviously pathological in 86 per cent., while the proportion diminishes as the results become unsatisfactory. Of recent years all operations have been conducted as exploratory laparotomies; that is, the small "interval" incisions have been abandoned. Of our 246 excellent cases only 6 were readmitted, while the 100 unsatisfactory yielded 26 readmissions.

INFECTIVE DISEASES.—*Typhoid fever with perforation.* All cases died, although it is fair to believe that in at least two cases the patients died of the typhoid fever and not of the sequelæ of the perforation or operation. The operation is, for the most part, done under local anæsthesia with the help of generous doses of morphine. Typhoid fever is not coming to operation any earlier nowadays because much time is lost in making blood examinations, which in the presence of the customary leucopænia are a waste of time.

Lymphadenitis, tuberculous. This is one of the most unsatisfactory problems. The class of cases chosen is usually those in whom operation could not be avoided; that is, with established or threatened suppuration. Twenty-two of these patients required subsequent operations for the removal of recurrent nodes, and it will be noted that no case was described as excellent. It must, however, be admitted that the classification is a little too severe, as a failure to record a case as excellent is often based on the presence of palpable lymph-nodes in the neck, which are practically always present in the neighborhood of the operative field. So far as feasible other remedial measures were effected—removal of diseased tonsils, care of the teeth, and sojourn in the country—but, of course, in only a limited number.

REPRODUCTIVE ORGANS (MALE).—*Hypertrophy of prostate.* The mortality is higher in these ward cases (4 deaths after removal of the prostate, 1 death after drainage under local anæsthesia) and does not represent the true status of prostatic surgery. Here again we have the neglected terminal stages in which we are forced to resort to some form of intervention. Our experience in private work, with well selected cases, is much more satisfactory. The removal in all cases was by the suprapubic method to which we are now committed. However, the results of these operations were, on the whole, quite good.

TUMORS (MALIGNANT).—This is the saddest part of our study. The tables speak for themselves and require little comment. However, fortunately, this study does not quite fairly represent the cancer situation, as this entire paper is based on the admissions to the wards, who are chiefly neglected, hopeless cases. Results in private work are better, but not sufficiently so to make us optimistic. Moreover, the cancer situation

has been complicated by the introduction of various therapeutic measures, some holding out some legitimate hope for their usefulness, others of the fake or "catch penny" sort. These result in confusion to the profession and deception to the public, and the pitiful cancer sufferer is made the victim, as he does not get a square deal.

An attempt has been made to analyze the opinions that cancer patients receive prior to their admission to the hospital. These have been collected by Doctor Farr in a paper entitled "Delay in the Treatment of Cancer."¹⁰

It will be noted that none of these cases is recorded as excellent. We do not feel that we can so classify them, owing to the possibility of a recurrence. We have, therefore, divided them into two groups—satisfactory (free from recurrence) and unsatisfactory (recurrence).

Carcinoma of the breast. In general our follow-up report of breast carcinoma shows that recurrence is much more frequent than one would believe from the literature. We believe that a patient should be in good condition six years after operation to count a case as cured. As our series only goes back six years we believe that not enough time has elapsed for us to draw definite conclusions. In our study of breast cases, we believe that cases come too late for operation and that progress must be made towards earlier recognition and earlier operation.

SUMMARY OF CARCINOMA CASES

(Including carcinoma, adenocarcinoma and epithelioma)

Number of cases	259
Number of known deaths	169
Number of cases living	41
(Ten of these unsatisfactory)	
Unknown	49
Number of operative cases	202
A. Number of deaths	130
In hospital	47
At home	83
B. Satisfactory results	29
C. Unsatisfactory results	8
D. Unknown	35
Of this number 20 were followed in part	
(12 satisfactory, 8 unsatisfactory)	
E. No specimen removed	15
Number of cases not operated upon	57
A. Number of deaths	39
In hospital	5
At home	34
B. Satisfactory (dubious diagnosis)	2
C. Unsatisfactory	2
D. Unknown	14
Of this number 2 cases were followed in part,	
both being unsatisfactory.	
Total number of cases	259

¹⁰ American Journal of the Medical Sciences, January, 1919.

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

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REPORT OF CARCINOMA CASES THAT ARE STILL LIVING

Diagnosis	Date of operation	Date of last report	Resulting condition
Breast	Nov., 1913	Dec., 1918	Satisfactory
Breast	Mar., 1914	July, 1918	Satisfactory
Breast	Aug., 1914	Sept., 1918	Unsatisfactory (recurrence)
Stomach*	Mar., 1914	Mar., 1919	Satisfactory
Stomach	July, 1914	Jan., 1919	Satisfactory
	Operation refused		
Face	Jan., 1914	Jan., 1919	Satisfactory
Lip	May, 1914	Apr., 1919	Satisfactory
Tongue	Sept., 1914	Feb., 1919	Satisfactory
Appendix	Feb., 1915	Mar., 1919	Satisfactory
Breast	July, 1915	Apr., 1919	Satisfactory
Breast	Mar., 1915	Mar., 1919	Satisfactory
Stomach*	Nov., 1915	Feb., 1919	Satisfactory
Face	Nov., 1915	Jan., 1919	Satisfactory
Breast	Jan., 1916	Dec., 1918	Satisfactory
Breast	Mar., 1916	Jan., 1919	Satisfactory
Breast	Aug., 1916	Feb., 1919	Satisfactory
Stomach*	Nov., 1916	Sept., 1918	Satisfactory
Uterus	Jan., 1916	Feb., 1919	Unsatisfactory (recurrence)
Uterus	Apr., 1916	Apr., 1919	Unsatisfactory (recurrence)
Lip	Mar., 1916	Apr., 1919	Satisfactory
Breast	Feb., 1917	Feb., 1919	Unsatisfactory (recurrence)
Breast	Apr., 1917	Jan., 1919	Satisfactory
Breast	June, 1917	Mar., 1919	Unsatisfactory (recurrence)
Breast	Feb., 1917	Feb., 1919	Satisfactory
Breast	June, 1917	Mar., 1919	Unsatisfactory (recurrence)
Lymph nodes	June, 1917	Oct., 1919	Satisfactory
Rectum	June, 1917	Mar., 1919	Satisfactory
Intestines	Oct., 1917	Apr., 1919	Satisfactory
	Operation refused		
Uterus	Aug., 1917	May, 1919	Satisfactory
Bladder	Oct., 1918	Mar., 1919	Satisfactory
Bladder	Mar., 1918	Apr., 1919	Satisfactory
Breast	Oct., 1918	Mar., 1919	Satisfactory
Breast	Aug., 1918	Apr., 1919	Unsatisfactory (recurrence)
Breast	May, 1918	Mar., 1919	Satisfactory
Larynx	Feb., 1918	Apr., 1919	Satisfactory
Lymph nodes	Aug., 1918	Jan., 1919	Satisfactory
Intestines	Oct., 1918	Feb., 1919	Unsatisfactory (recurrence)
	Operation refused		
Uterus	Dec., 1918	Apr., 1919	Unsatisfactory (recurrence)
Uterus	Mar., 1918	Feb., 1919	Satisfactory
Uterus	Mar., 1918	Nov., 1918	Satisfactory
Lip	Feb., 1918	Apr., 1919	Unsatisfactory (recurrence)

* Diagnosis probably wrong—no specimen.

CHARLES L. GIBSON

REPORT ON "UNKNOWN RESULTS"

Number of unknown cases 49
(Of this number 14 had no operation.)

Cases having no note 27

Cases followed in part 22

Diagnosis	Date of operation	Last note
Breast	Sept., 1913	June, 1914: Satisfactory
Breast	Mar., 1913	No note
	(No operation)	
Intestines	Nov., 1913	July, 1916: Satisfactory
Maxilla	Apr., 1913	No note
Fallopian tubes	June, 1913	No note
Stomach	Feb., 1913	No note
	(No operation)	
Uterus	July, 1913	No note
	(No operation)	
Omentum	Mar., 1913	No note
Breast	June, 1914	Mar., 1917: Satisfactory
Breast	May, 1914	No note
Intestines	May, 1914	Oct., 1914: Losing strength rapidly. In bed all the time
Intestines	Apr., 1914	Aug., 1914: Slightly improved
Lymph nodes	Nov., 1914	Dec., 1915: Slightly improved
Uterus	Aug., 1914	No note
	(No operation)	
Uterus	Aug., 1914	No note
Ovary	Feb., 1914	No note
Lip	Dec., 1914	No note
Lip	Feb., 1914	No note
Lip	Jan., 1914	July, 1916: Satisfactory
Penis	Jan., 1914	Jan., 1915: Satisfactory
Breast	Oct., 1915	Feb., 1916: Satisfactory
Bladder	Aug., 1915	Dec., 1915: Unimproved
Intestines	Sept., 1915	No note
Prostate	Apr., 1915	No note
Stomach	May, 1915	No note
Stomach	May, 1915	June, 1915: Feels better; has returned to work
Stomach	May, 1915	No note
Uterus	Oct., 1915	Jan., 1916: Living on coal barge
Lip	Aug., 1915	Feb., 1916: Satisfactory
Breast	Aug., 1916	Apr., 1918: Losing ground rapidly
	(No operation)	
Esophagus	July, 1916	July, 1917: Unimproved
Rectum	Nov., 1916	No note
	(No operation)	
Stomach	Dec., 1916	Jan., 1917: Return of symptoms
Face	Jan., 1916	Dec., 1916: Satisfactory
Vulva	June, 1916	Nov., 1916: Marked recurrence
Breast	June, 1917	Nov., 1917: Satisfactory.
Breast	June, 1917	Apr., 1918: Extensive recurrence

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

REPORT ON "UNKNOWN RESULTS"—*Continued*

Diagnosis	Date of operation	Last note
Intestines	Mar., 1917	No note
Intestines	Aug., 1917	No note
	(No operation)	No note
Prostate	Dec., 1917	
	(No operation)	No note
Rectum	Jan., 1917	
	(No operation)	No note
Breast	Mar., 1918	
Intestines	Aug., 1918	No note
	(No operation)	
Intestines	July, 1918	No note
	(No operation)	
Prostate	Oct., 1918	No note
	(No operation)	
Stomach	Mar., 1918	
Thyroid	Aug., 1918	
	(No operation)	Nov., 1918: Satisfactory
Ovary	Aug., 1918	
Tongue	Mar., 1918	
	(No operation)	Nov., 1918: Very ill

The educational value of the information obtained by a study of end results has been particularly impressed on the whole staff as time goes on. It was not long before several surprising factors became apparent, and we were able to substitute definite data for vague impressions. In several instances it came as a shock that we were getting poor or bad results of which we were in blissful ignorance, and were stimulated to improve our work with beneficial results. We have a weekly conference of the whole staff which includes a report of the follow-up work of the previous week and, in addition, quarterly and annual reports so that all members of the staff are constantly in touch with the situation.

In view of our enforced revision of judgment concerning our end results obtained by the follow-up system, we feel a certain reluctance to accept statements on such matters unless there is evidence that a systematic effort is made to check up such results.

The accompanying tables give the details of the results obtained:

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER 31, 1913.

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
<i>Congenital Abnormalities and Malformations:</i>											
Malformations.....	87	5(1)*	73	Tonsils..... Neurasthenia..... Hare lip.....	1 0 Died 0	57	45	24	17	4	
<i>The Blood:</i>											
Streptococcus blood infection.....	1	0	0	.....	0						
<i>Bones and Cartilages:</i>											
Abscess of bone.....	2	0	2	.....	...	2	0				
Faulty union.....	22	0	22	Faulty union (4 cases)..... Fractured femur.....	2 Died	19	17	2	13	2	
Necrosis.....	3	0	3	Abscess.....	1	2	2	...	2		
Osteomyelitis.....	104	9	93	Osteomyelitis (11 cases).....	8	69	50	10	29		2
Ostitis deformans.....	1	0	1	.....	...	1	1	...	1		
Periostitis.....	5	0	2	.....	...	3	2	...	1	...	1
<i>Bursæ:</i>											
Bursitis.....	26	0	20	Bursitis..... Ulcer-leg.....	1 1	19	14	8	5	1	
<i>The Circulatory System:</i>											
Aneurysm.....	8	1	8	Aneurysm.....	1	6	3	...	2	1	
Arteriosclerosis.....	1	0	1	.....	...	1	1	...	1		
Cardiac valvular disease.....	2	0	0	.....	...	0	0	...			
Endarteritis obliterans.....	8	0	5	Endarteritis.....	3	8	6	1	3	1	1
Myocarditis.....	1	0	0	.....	...	0					
Thrombosis.....	1	1	1	.....	...				
Varicose veins.....	49	0	44	Varicose veins.....	1	42	32	12	18	2	
<i>Digestive System:</i>											
Appendicitis, acute.....	789	36(2)	782	Fecal fistula..... Ventral hernia (11 cases)..... Salpingitis..... Tonsils (3 cases)..... Abdominal sinus..... Cystitis (1)..... P. O. adhesions (2)..... Cholelithiasis..... Constipation.....	3 10 3 2 1 0 0 0 0	623	502	313	182	5	2

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Appendicitis, chronic.....	586	3	552			553	414	246	67	100	1
Abscess of omentum.....											1
Adenoma of thyroid.....											1
Abscess of leg.....											1
Actinomycosis of colon (1).....											Died
Foreign body in abdominal sinus.....											1
Pelvic abscess.....											1
Inguinal hernia.....											1
Cystitis (1).....											0
P. O. adhesions (7 cases).....											5
Anteflexion of uterus.....											1
Tonsils.....											1
Hemorrhoids.....											2
Malformation of spinal column.....											1
Chronic myositis (1).....											0
P. O. wound.....											1
Constipation (2).....											0
Hysteria (1).....											0
Gastroptosis.....											2
Lacerated pelvic floor.....											1
Fissure of anus.....											1
Cholecystitis.....											1
Contusion of breast.....											0
Gastric ulcer (2).....											0
Furunculosis.....											0
Foreign body in abdominal wall.....											1
Ventral hernia.....											1
Inguinal hernia.....											1
Circumcision.....											1
Cystoma of ovary.....											1
Pyonephrosis.....											1
Tubercular intestine.....											Died
Stricture of urethra.....											1
Chronic appendix.....											2
.....											...
.....											1
Abdominal sinus.....											1
Ventral hernia.....											0
.....											...
.....											...
Ventral hernia.....											1
.....											...
Colitis.....	7	2	2			3	3	...	1	2	
Constipation.....	48	0	6			4	4	...	2	2	
Diverticulitis.....	2	0	2			1	1	...	...	...
Fecal fistula.....	2	0	2			2	0	...	...	...
Dilatation of cecum.....	1	0	1			1	1	...	1		
Gastro-enteritis.....	5	0	0			0					
Mesenteric thrombosis.....	6	6(1)	6								
Intestinal obstruction.....	38	17(2)	36			17	14	7	5	2	
Intestinal hemorrhage.....	1	0	1			1	1	1	1		

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
Digestive System: Continued											
Viscerotiposis.....	14	0	2	.....	...	2	2	...	2		
Ulcer of caecum.....	1	0	1	.....	...	1	1	1			
Stricture of intestine.....	1	1	1	.....	...				
Abscess of liver.....	6	0	6	.....	1	4	3	2	...	1	3
Cirrhosis of liver.....	7	3	5	.....	...	4	4	...	1	...	2
Cholelithiasis and cholecystitis.....	214	14(2)	179	.....	Died	165	142	48	80	12	
				.....	P. O. adhesions.....						
				.....	Constipation.....	4					
				.....	Ventral hernia.....	0					
				.....	Carcinoma of gall bladder.....	2					
				.....	Fibromyoma of uterus.....						
				.....	Tubercular vertebra.....	0					
				.....	Cholelithiasis.....						
				.....	Strangulated inguinal hernia.....	1					
	6	2(1)	4	.....	Ventral hernia.....	3	2	...	1	1	
Pelvic abscess.....	36	1	25	.....		24	23	3	13	7	
Adhesions of peritoneum.....	18	10(2)	16	.....		7	5	2	2	1	
Peritonitis.....	561	1	559	.....		281	227	173	53	...	1
Tonsils and adenoids.....				.....						
				.....	Circumcision.....						
				.....	Pulmonary tuberculosis.....						
				.....	Tubercular hip.....						
	3	1	2	.....		2	1	1	...	...
Abscess of pharynx.....	3	0	2	.....		2	2	1	...	...
Foreign body in oesophagus.....	1	0	0	.....		1	1	...	2	2	
Stricture of oesophagus.....	2	0	2	.....		2	2	...	2	2	
Ulcer of mouth.....	13	0	11	.....		2	2	...	2	2	
Alveolar abscess.....	9	3	9	.....		6	6	4	2		
Pancreatitis.....				.....						
Abscess about rectum and fistula in ano.....	98	...	97	.....		61	46	14	26	6	
				.....	Axillary abscess.....						
				.....	Abscess-rectum.....						
				.....	Stricture urethra.....						
				.....	Fistula in ano.....						
				.....	Inguinal hernia.....						
				.....	Hemorrhoids.....						
				.....	Lacerated tendons.....						
				.....	Stricture of rectum.....						

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Fissure of anus.....	4	0	4	.....	Died	4	3	45	3
Hemorrhoids.....	191	0	184	.....	I	14	73		
Prolapse of rectum.....	3	0	3	.....	0	2	2	I	I
Proctitis.....	1	0	1	.....	...	0	...	2	
Stricture of rectum.....	4	0	2	.....	...	3	2	2	
Ulcer of rectum.....	2	0	1	.....	...	1	1	I	
Acute dilatation of stomach.....	1	0	1	.....	...	1	1	I	
Gastritis.....	4	0	0	.....	...	0	...		
Foreign body in stomach.....	1	0	0	.....	...	0	...		
Hypochlorhydria.....	2	0	1	.....	...	0	...		
Pyloric spasm.....	2	0	2	.....	...	0	...		
Stenosis of pylorus.....	1	I	1	.....	...	2	I	...	I
Ulcer of stomach and duodenum..	93	7(1)	70	.....	Died	62	55	22	4
Ulcer of stomach, perforating.....	40	11(1)	39	.....	0	29	26	16	
<i>Ductless Glands and Spleen:</i>					Died				
Exophthalmic goitre.....	12	2	9	.....	I	8	5	3	I
Simple cystic goitre.....	12	0	9	.....	...	8	4	2	
Suppurative thyroiditis.....	1	0	1	.....	...	1	1	I	
Diseases of spleen.....	11	I	9	.....	Died	6	6	I	...
<i>The Ear:</i>					Died				
Otitis media and mastoiditis.....	16	0	8	.....	...	13	8	4	
<i>The Eye:</i>					...				
Ulcer of cornea.....	1	0	0	.....	...	1	0		
<i>Hernia:</i>									
Epigastric.....	4	0	4	.....	I	4	3	2	I
Femoral.....	54	I	53	.....	2	46	40	10	3
Relaxed pelvic floor.....				.....	I				
Prolapse of uterus.....				.....	I				

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
<i>Herniae: Continued</i>											
Femoral, strangulated.....	11	1	11	.....	...	9	9	5	4		
Inguinal.....	872	2	849	Hernia, opposite side.....	10	780	539	319	209	11	
				Recurrence.....	9						
				Cellulitis of wound (2).....	1						
				Tonsils.....	2						
				Hydrocele.....	2						
				Endothelioma of submaxillary nodes	0						
				Varicose veins.....	1						
				Carcinoma of bladder.....	1						
				Hemorrhoids.....	2						
				Acute appendicitis.....	3						
				Congenital malformation of testicle.	0						
				Tubercular vertebra.....	1						
				Inguinal abscess.....	1						
				Femoral hernia.....	1						
Inguinal, strangulated.....	41	6	41	Tubercular peritoneum.....	2	34	25	16	7	1	1
Umbilical.....	22	2	21	Strangulated hernia, opposite side..	1	17	14	4	9	1	
Umbilical, strangulated.....	9	5(1)	9	Fibroid uterus.....	0	4	3	...	2	...	1
				Inguinal hernia.....	1						
Ventral.....	49	2	39	Salpingitis.....	2	33	26	17	8	1	
				Tubercular vertebra.....	0						
				Hemorrhoids.....	1						
Ventral, strangulated.....	7	3(1)	5	Intestinal obstruction.....	Died	2	1	...	1		
<i>Infective Diseases:</i>											
Abscess.....	115	4	110	Abscess.....	4	73	52	20	25	5	2
				Chronic appendix.....	1						
				Tubercular vertebra.....	0						
				Tubercular peritonitis.....	Died						
Carbuncle.....	21	2	21	.....	...	8	7	3	4		
Cellulitis.....	100	5	90	P. O. hemorrhage.....	1	71	53	13	34	6	
				Contracture.....	1						
				Abscess.....	0						
Erysipelas.....	2	0	0	.....	...	3	3	1	2		
Furunculosis.....	5	0	5	.....	...				

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

[illegible]

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-ported	Excel- lent	Satis- factory	Unsat- isfac- tory	Died at home
<i>Lymphatic System: Continued.</i>											
Lymphadenitis, tubercular				General tuberculosis.....	0						
Elephantiasis.....	2	1	2	Tonsils.....	3	1	1	...	...	1	
Hodgkin's.....	4	0	3	Osteomyelitis.....	...	3	3	...	2	1	
<i>Miscellaneous:</i>				.....	...				
Miscellaneous diseases.....	57	2	34	.....	...	22	18	4	10	3	1
<i>Muscles and Tendons:</i>				.....	...	14	12	9	3		
Diseases of muscles and tendons..	20	0	16	.....	...	5	5	...	2	3	
<i>Nervous System:</i>				.....	...	2	2	2	2	...	1
Diseases of nervous system.....	31	4	8	Appendicitis, acute.....	1	2	2	...	2		
<i>Reproductive Organs (Female):</i>				Metrorrhagia.....	1	3	3	...	2	...	
Dysmenorrhea.....	3	0	2	Chorio-epithelioma of uterus.....	1						
Metrorrhagia.....	4	0		Endometritis.....	1	0	0				
Sterility.....	1	0	0	.....	...	1	1				
Galactocoele.....	1	0	1	.....	...	0	0				
Hypertrophy of breast.....	1	0	1	.....	...	0	0				
Mastitis.....	44	0	40	Same.....	4	36	26	19	5	1	1
Pelvic cellulitis.....	3	1	3	Cystoma ovary.....	1	2	2	1	1		
Extra-uterine gestation.....	52	3(1)	51	Endometritis.....	1	45	33	18	11	4	
				Cystoma ovary.....	1						
				Phlebitis.....	0						
				Intestinal colic.....	0						
Hematosalpinx.....	1	0	1	.....	...	1	1	1			
Oophoritis.....	9	0	8	Acute gastritis.....	...	7	6	3	2	1	
Salpingitis, acute.....	47	3(1)	43	Tubercular peritoneum.....	0	37	27	14	11	2	
				Cystoma ovary.....	1						
				Ventral hernia.....	1						
				Rectovaginal fistula.....	1						
Salpingitis, chronic.....	244	5	211	Pyelitis.....	0	165	118	39	67	11	1
				P. O. adhesions.....	1						
				Ganglion.....	1						

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

	I	Died	I
Ventral hernia (2).....	10	8	2
Intestinal obstruction.....	2	1	5
Ventral hernia.....	19	15	1
Pelvic peritonitis.....	0	0	...
Pelvic abscess.....	1	1	4
Endotrachelitis.....	0	0	...
Appendicitis, chronic.....	1	1	...
Cystoma ovary.....	0	0	...
Relaxed pelvic floor.....	0	0	...
Fibromyoma.....	1	1	...
Salpingitis (2).....	0	0	...
Abortion, incomplete.....	1	1	...
.....
Anteversion.....	13	13	13
Abscess vulva.....	2	2	2
Prolapse.....	21	21	21
Cystocele.....	6	6	6
.....	61	61	61
Salpingitis.....	0	0	0
Endometritis.....	0	0	0
Incomplete abortion.....	118	118	118
Cystoma of ovary.....	0	0	0
Salpingitis (5).....	3	3	3
Varicose veins.....	1	1	1
Extra-uterine.....	1	1	1
Tubercular appendix.....	2	2	2
Abscess about rectum.....	15	15	15
.....	4	4	4
.....	9	9	9
.....	2	2	2
.....	1	1	1
.....	1	1	1
.....	1	1	1
.....	109	109	109
Endotrachelitis.....	2	2	2
Fibroid uterus.....	3	3	3
Hæmatoma.....	1	1	1
Endometritis.....	1	1	1
Pleurisy.....	0	0	0
Cystoma.....	1	1	1
Pyelitis.....	0	0	0

CHARLES L. GIBSON

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-ported	Excel- lent	Satis- factory	Unsat- isfac- tory	Died at home
<i>Reproductive Organs (Female):</i>											
<i>Continued</i>											
Vaginitis.....	2	0	0	Salpingitis.....	1						
<i>Reproductive Organs (Male):</i>				Uteral colic.....	0						
Phimosis and redundant prepuce..	73	0	68	Abscess rectum.....	1	0					
Abscess of prostate.....	5	0	4	Tonsils.....	2	25	20	18	2		
Hypertrophy of prostate.....	22	5	19	Adenitis.....	0	2	2	1	...	1	1
				Hydrocele.....	1	14	10	3	5		
Abscess of scrotum.....	2	0	1	Stricture of urethra.....	1						
Calculeus of prostate.....	1	0	0	Inguinal hernia.....	1	0					
Prostatitis.....	1	0	0	.....	...	1	0				
Acute orchitis.....	1	0	0	.....	...	1	0				
Hydrocele.....	65	0	62	.....	...	0		20	10	1	
				Hydrocele.....	2	45	31				
Varicocele.....	79	0	78	Abscess scrotum.....	1						
Spermatocele.....	2	0	2	Tubercular nodes.....	1	60	36	18	17	1	
Epididymitis.....	9	0	4	Cellulitis of scrotum.....	...	1	1	...	1		
<i>Parasites:</i>				Epididymitis.....	...	3	3	2	1		
Entamoebic dysentery.....	1	0	1	.....	...	1	1	1			
Echinococcus cysts liver.....	4	2	4	.....	...	2	1	1			
Spleen.....	1	0	1	.....	...	1	1	...	1		
<i>Respiratory System:</i>				Inguinal hernia.....	1	3	2	1	1		
Abscess of lung.....	4	1	4	Suppurative pleurisy (?).....	5	49	45	26	17	1	1
Suppurative pleurisy.....	96	14(1)	89	Abscess of lung (2).....	2						
				Broncheatasis.....	1 died						
<i>Lobar pneumonia.</i>				.....	1						
<i>Nasal Passages and Accessory Sinuses:</i>											
Sinusitis.....	3	0	3	.....	...	3	2	1	1		

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

[illegible]

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
<i>Tumors (Benign): Continued</i>											
Fibromyoma of uterus.....	145	4	133	Carcinoma of uterus..... Cholecystitis..... Vulvo-vaginal abscess..... Adhesions..... Lacerated pelvic floor..... Constipation.....	1 1 1 2 1 0	108	81	34	38	4	5
<i>Tumors (Malignant):</i>											
Carcinoma of											
Appendix.....	2	1	2	.....	.....	1	1	.....	1	.....	1
Bartholin's gland.....	1	0	1	.....	.....	1	1	.....	.....	.....	5
Bladder.....	10	2	7	.....	.....	8	7	.....	2	.....	25
Breast.....	51	0	48	Recurrence.....	Died	50	41	.....	12	4	4
Gall-bladder.....	6	2	5	.....	.....	4	4	.....	.....	.....	12
Intestines.....	33	11	25	Recurrence.....	1	21	14	.....	1	1	.....
Larynx.....	1	0	1	.....	.....	1	1	.....	.....	.....	3
Liver.....	6	3	6	.....	.....	3	3	.....	.....	.....	3
Lymph nodes.....	6	0	5	.....	.....	6	5	.....	2	.....	3
Maxilla.....	3	1	3	.....	.....	2	1	.....	.....	.....	1
Oesophagus.....	4	1	4	.....	.....	3	2	.....	.....	.....	2
Pancreas.....	7	4(1)	3	.....	.....	3	3	.....	.....	.....	3
Peritoneum.....	2	2	2	.....	.....	.....	.....	.....	.....	.....	.....
Prostate.....	5	1	2	.....	.....	4	1	.....	.....	.....	1
Rectum.....	11	3(1)	7	.....	.....	8	6	.....	.....	.....	5
Stomach.....	40	11(1)	30	Recurrence.....	Died	28	22	.....	1	.....	18
Thyroid.....	2	1(1)	0	.....	.....	1	0	.....	4	.....	.....
Fallopian tubes.....	3	0	3	.....	.....	3	2	.....	.....	.....	2
Uterus.....	32	1	21	Recurrence.....	3	29	25	.....	3	3	19
Ovaries.....	5	2	5	.....	2 died	3	1	.....	.....	.....	1

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Endothelioma of	3	0	3	...	...	3	1	...	1
Nodes of neck.	1	0	1	...	...	1	1	...	...
Ovary.	1	0	1	...	...	1	1	...	...
Parotid.	1	0	1	...	...	1	1	...	...
Arm.	1	0	1	...	...	1	1	...	...
Epithelioma of									
Face.	3	0	3	...	...	3	2	...	...
Lip.	8	0	8	...	...	8	4	...	...
Penis.	1	0	1	...	...	1	0	...	...
Tongue.	14	1(1)	8	...	...	13	12	...	...
Vulva.	1	0	0	...	...	0		...	...
Hypernephroma of									
Kidney.	1	1(1)	0	...	...			...	...
Sarcoma of									
Abdominal wall.	1	0	1	...	...	1	1	...	...
Bones.	7	0	7	...	...	6	6	...	...
Breast.	1	0	1	...	...	1	0	...	...
Leg.	1	0	1	...	...	1	0	...	...
Intestines.	1	1	1	...	...			...	...
Gum.	1	0	1	...	...	1	1	...	...
Kidney.	1	0	1	...	...			...	...
Lymph nodes.	4	0	4	...	...	4	1	...	...
Rectum.	1	0	1	...	...	1	0	...	...
Spleen.	1	1	1	...	...			...	...
Tendon sheath.	1	0	1	...	...	1	1	...	...
Testicle.	1	0	1	...	...	1	1	...	...
Teratoma, malignant.				...	...			...	...
Retroperitoneal nodes.	1	0	1	...	...	1	1	...	...
Adenocarcinoma of									
Omentum.	2	0	2	...	...	1	0	...	...
Adenopapilloma.	1	1	1	...	...			...	...
Fibrosarcoma of									
Finger.	1	0	1	...	...	1	1	...	...
Ovary.	1	0	1	...	...	1	0	...	...
Lymphosarcoma of									
Intestines.	1	0	1	...	...	1	0	...	...
Jaw.	1	1(1)	0	...	...			...	...
Lymph nodes.	2	0	2	...	...	2	2	...	...

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis.	No. of cases	No. of deaths	No. of operations	Readmitted	2nd operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
<i>Tumors, Malignant: Continued</i>											
Myosarcoma of Intestines.....	1	0	1	.....	...	1	1	...	1		
Myxochondro-endothelioma	2	0	2	.....	...	2	1	...	1		
Parotid.....	4	0	4	.....	...	4	1	...	1		
Submaxillary gland.....											
<i>Urinary Organs:</i>											
Abscess urethra.....	1	0	1	Fistula in ano.....	Died	1	0				
Calculus in bladder.....	6	0	4	Calculus.....	0	3	2	...	2		2
Cystitis.....	16	2	3	Pulmonary tuberculosis.....	...	5	4	...	2	...	
Calculus in ureter.....	10	0	4	Stricture of urethra.....	1	6	6	1	3		
Calculus in urethra.....	2	0	2	.....	...	2	2	...	2		
Caruncle of urethra.....	1	0	1	.....	...	1	1	1	1		
Cyst of kidney.....	2	0	2	.....	...	2	2	1	1		
Hæmaturia.....	3	0	3	.....	...	2	1	1	1		1
Hydronephrosis.....	2	0	2	.....	...	2	2	...	1		
Incontinence.....	1	0	0	.....	...	0	0				
Leukoplakia of bladder.....	1	0	0	.....	...	1	0				
Nephralgia.....	1	0	0	.....	...	0	0				
Nephritis.....	10	5(4)	6	.....	...	4	3	1	1		1
Nephrolithiasis.....	42	2	26	Hæmaturia.....	0	28	23	13	9	1	
				Nephrolithiasis.....	1						
				Pleurisy.....	0			3	2	1	1
Nephroptosis.....	10	0	7	.....	...	7	7	3	2		
Perinephritic abscess.....	30	2(1)	28	.....	...	26	19	14	3	2	
Pylcitis.....	16	0	2	.....	...	9	5	1	4		
Retention of urine.....	2	1	1	.....	...	0					
Stricture of urethra.....	31	1	29	Fistula in ano.....	2	21	10	3	4	2	1
				Acute appendicitis.....	1						
Stricture of ureter.....	4	0	4	.....	...	2	2	...	2		
Stricture neck of bladder.....	1	0	1	.....	...	1	1	...	1		
Ureteral colic.....	4	0	0	Abscess prostate.....	0	4	4	...	3	1	
<i>Obstetrical Conditions:</i>											
Abortion, incomplete.....	102	0	99	Acute cystitis.....		66	44	11	27	5	1

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

[illegible]

REPORT OF FOLLOW-UP WORK FROM FEBRUARY, 1913, TO DECEMBER, 1918, INCLUSIVE.—Continued

Diagnosis	No. of cases	No. of deaths	No. of operations	Readmitted	and operation	To return	Re-reported	Excellent	Satisfactory	Unsatisfactory	Died at home
<i>Injuries: Continued</i>											
Gunshot wound of											
Radius.....	1	0	1	.....	...	1	0	...	1		
Scapula.....	1	0	1	.....	...	1	1	...			
Dislocation of											
Ankle.....	2	0	1	.....	...	2	2	2		1	
Cartilage.....	7	0	6	.....	...	7	7	3	3		
Elbow.....	11	0	4	.....	...	9	7	1	1		
Inferior maxilla.....	1	0	0	Arthritis.....	1	1	1	...	1		
Metatarsals.....	1	0	0	.....	...	1	1	...	1		
Metacarpals.....	1	0	1	.....	...	1	1	...	1		
Hip.....	1	0	0	.....	...	1	1	...	1		
Radius.....	1	0	0	.....	...	1	1	...	1		
Ribs.....	1	0	1	.....	...	0	1	...			
Humerus.....	20	0	6	Fracture of humerus.....	0	11	7	1	4	2	
.....				Dislocation.....	0	2	2	1	0	1	
Wrist.....	5	0	2	.....	...				
Foreign body in											
Joint.....	8	0	8	.....	...	5	5	...	4	1	
Bursa, prepatellar.....	1	0	1	.....	...	1	1	...	1		
Sprain of											
Sacro iliac joint.....	2	0	0	.....	...	1	1	1	1		
Synovitis, traumatic.....	3	0	1	.....	...	1	1	...			
Contusion of											
Joint.....	3	0	0	.....	...	0					
Punctured wound											
Knee.....	2	0	2	.....	...	1	1	...	1		
Injuries to											
Digestive system.....	29	11(1)	19	Cystoma.....	1	13	10	4	5	...	1
Ear.....	2	0	2	.....	...	2	2	2			
Muscular system.....	37	0	37	Pelvic abscess.....	1	33	31	2	25	4	
Nervous system.....	5	1	2	.....	...	0					
Reproductive organs.....	5	0	2	.....	...	4	3	3			
Respiratory system.....	4	1(1)	2	Bronchiectasis.....	Died	2	2	2			
Spleen.....	2	0	2	Ventral hernia.....	1	2	1	1			

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Urinary organs.....	4	1	2	Ventral hernia.....					1	2	1	1	2		
Abdominal wall.....	11	3(1)	9	.....					...	6	5	3	3	2	
Back.....	12	1(1)	7	.....					...	5	3	3	1	1	
Chest wall.....	4	1(1)	1	.....					...	2	2	...	4	10	
Extremities, lower.....	42	2	20	Cicatricial contracture.....					1	24	15	4	10	1	
Extremities, upper.....	61	2(1)	49	Ulcer.....					0	45	37	22	12	3	
Face and scalp.....	25	1(1)	10	Skin grafting.....					1	10	8	3	4	1	
Neck.....	4	0	3	Cellulitis.....					0	1	1	1	1	1	
Perineum.....	2	0	1	Retroversion.....					...	2	2	...	1	1	
Miscellaneous and multiple injuries	20	7(5)	8	.....					...	7	6	...	5	1	
				(Of this number 27 died)					367	5707	4324	1921	1827	393	183
Readmission	8028	358	6808												
Total	428	27	367												
	8456	385	7175												

* Under "Number of Deaths," figures in parentheses denote number included in other figures who died without operation. Of the 358 cases who died in the Hospital, therefore, 60 of these had no operation. Operative mortality, 4 per cent.

Note.—Total number of known deaths, both in and out of Hospital, 568. (Of this number 3 patients died of influenza after leaving the hospital.) Therefore of 8028 cases 7 per cent. are known to be dead.

Note.—Of 5707 cases asked to return for examination 75.5 per cent. returned. This percentage is lowered by the inclusion of the two unsatisfactory periods, i.e., the year 1913 and the period of the war. Our percentage under normal conditions has been as follows: Mar. 11, 1916 (three months report), 93 per cent.; September, 1916 (six months report) 90.6 per cent.; Dec., 1916 (three months report), 88.7 per cent.; April, 1917 (three months), 90.6 per cent.

CHARLES L. GIBSON

APPENDIX

CLASSIFICATION OF PATIENTS RETURNING FOR SECOND OPERATION *

	No. of cases	No. of deaths
Malformations:		
Harelip	1	1
Spinal column	1	
Bones and Cartilages:		
Faulty union	8	
Osteomyelitis	12	
Bursitis	1	
The Circulatory System:		
Aneurism	1	
Endarteritis	3	
Varicose veins	3	
The Digestive System:		
Acute appendicitis	5	
Chronic appendicitis	4	
Fecal fistula	3	
Intestinal obstruction	2	2
Abscess of liver	1	
Cholelithiasis	4	1
Stenosis of gall-bladder	1	1
Pelvic abscess	3	
Adhesions of peritoneum (P. O.)	13	
Tonsils and adenoids	12	
Abscess about rectum	4	
Fistula in ano	13	
Fissure of anus	1	
Stricture of rectum	1	
Hemorrhoids	6	
Gastroptosis	2	
Gastric ulcer	2	
Gastric ulcer, perforating	1	1
Duodenal ulcer	1	1
Ductless Glands and Spleen:		
Exophthalmic goitre	1	
Banti's disease	1	1
Splenomegaly	1	1
Herniæ:		
Femoral hernia	1	
Inguinal-hernia	26	
Inguinal hernia, strangulated	3	
Ventral hernia	22	1
Umbilical hernia	1	
Infective Diseases:		
Abscess	13	
Cellulitis	4	
Syphilis	1	
Tuberculosis of intestines	1	1

* The second operation is often for a condition different from the original disease, *e.g.*, hemorrhoids following chronic appendicitis. The patient's history card is filed under the original condition for which he entered the hospital. Subsequent admissions are entered on the same card, second diagnoses being cross referenced.

FOLLOW-UP SYSTEM IN A HOSPITAL SERVICE

Infective Diseases (Continued):

Tuberculosis of (continued):

	No. of cases	No. of deaths
joints	8	
bones	4	
peritoneum	5	I
costal cartilage	I	
skin	I	
epididymis	2	
fallopian tubes	I	
properitoneal tissue	I	
kidney	I	
lymph nodes	23	
Appendix	I	

Joints:

Ankylosis	3
Arthritis	3
Talipes	I

Miscellaneous:

Abdominal sinus	3
Foreign body in abdominal sinus	I
P. O. wound	I
Foreign body in abdominal wall	I
P. O. hemorrhage	I
Cicatricial contracture	2
Ganglion	I
Hæmatoma	I
Revision of amputation stump	I
Foreign body in thigh	I
Skin grafting	I

Parasites:

Actinomycosis of colon	I	I
------------------------------	---	---

Reproductive Organs (Female):

Metrorrhagia	I
Mastitis	4
Extrauterine gestation	I
Chr. salpingitis	16
Anteflexion of uterus	I
Retroversion of uterus	I
Prolapse of uterus	2
Anteversio	I
Relaxed pelvic floor	3
Lacerated pelvic floor	2
Endometritis	7
Endotrachelitis	I
Vulvo-vaginal abscess	2

Reproductive Organs (Male):

Circumcision	2
Hydrocele	5

Respiratory System:

Suppurative pleurisy	5	
Abscess of lung	2	I
Bronchiectasis	2	I

Skin, Hair and Nails:

Ulcer of leg	I
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CHARLES L. GIBSON

	No. of cases	No. of deaths
Tumors (Benign) :		
Adenoma of thyroid	1	
Cystoma of ovary	8	
Fibromyoma of uterus	7	
Teratoma	1	
Lipoma	2	
Osteoma	1	
Tumors (Malignant) :		
Carcinoma of gall-bladder	1	1
Carcinoma of stomach	2	2
Carcinoma of bladder	1	
Carcinoma of breast	1	1
Carcinoma of uterus	4	1
Epithelioma of uterus	1	
Epithelioma of tongue	3	
Carcinoma of intestines	1	
Sarcoma of bones	2	1
Sarcoma of breast	1	1
Sarcoma of kidney	1	1
Sarcoma of omentum	1	1
Urinary Organs:		
Pyonephrosis	1	
Stricture of urethra	4	
Calculus in ureter	1	
Calculus in bladder	1	1
Nephrolithiasis	1	
Acute cystitis	1	
Obstetrical Conditions:		
Incomplete abortion	4	
Injuries:		
Lacerated wound of tendon	1	
Fracture of femur	1	1
Total	367	27

WAR SURGERY UNDER FRONT-LINE CONDITIONS*

REPORT OF THE WORK OF CASUAL SURGICAL TEAM NO. 506 (ORIGINALLY NO. 6) FROM JUNE 18, 1918, TO AUGUST 8, 1918

BY ELLIOTT C. CUTLER, M.D.

OF BOSTON, MASS.

CAPTAIN MEDICAL CORPS, A. E. F.; CHIEF OF TEAM

PERSONNEL OF CASUAL SURGICAL TEAM NO. 506 (NO. 6): CAPTAIN ELLIOTT C. CUTLER, MEDICAL CORPS; CAPTAIN CARLETON METCALF, MEDICAL CORPS; FIRST LIEUT. PAUL B. STEELE, MEDICAL CORPS; LILLIAN E. BOWEN, R.N., A.N.C.; MARY A. OWENS, R.N., A.N.C.; PRIVATE LOUIS WISCHMAN, MEDICAL DEPARTMENT; PRIVATE HENRY C. WARD, MEDICAL DEPARTMENT

Foreword.—The following is a summary of the work performed by Casual Surgical Team No. 6 (No. 506 as per new orders) from June 18, 1918, to August 8, 1918. During this period we have records of 576 cases operated upon by the team. Presumably about 50 to 75 more cases were operated without our ever obtaining any records. The period covers two distinct periods of military activity.

During the first period from June 18 to July 15, 1918, the team was working in Evacuation Hospital No. 7 and Mobile Hospital No. 1, which were established as a single group at Coulommiers, France. The cases arriving at these two hospitals during this period came in successive groups, usually covering two to three days, due to efforts of the American troops in the line to dislodge the enemy from a difficult wooded country and to straighten out and improve their battle front. At no time was the influx of patients great enough to overtax the ability of these two hospitals to handle them well, and as a result careful and deliberate operations were almost always possible.

The second period began July 15, with the general attack of the enemy along the Marne River. From this date on, until the closure of these records with our transfer to Evacuation Hospital No. 3 as Surgical Director, the

* EDITOR, ANNALS OF SURGERY:

I am directed by the Surgeon General to say that the inclosed paper, "Report of the Work of Casual Surgical Team, No. 506, etc.," is authorized for publication. It is thought that if published in full, it would be interesting as a typical A. E. F. Team report.

LOY McAFEE,

Contract Surgeon, U. S. Army,
Secretary, Board of Publications.

September 29, 1919.

pressure of work was great and excessive almost without respite. We were moved July 31 to the southern bank of the Marne, east of Château-Thierry, where we continued to work in Mobile Hospital No. 1 until we were moved to Evacuation Hospital No. 3 at Crezancy August 8, 1918. There was one period of twenty-four hours' continuous work, two hours' sleep, and then twenty-four hours' more work. It was a most trying experience and I take the greatest pleasure in attesting here to the energy, ability, devotion to duty, and zeal of the assistants, officers, nurses, and enlisted men. Their conduct throughout was exemplary and worthy of the highest praise.

Captain Carleton R. Metcalf, since promoted to the rank of major, was an excellent assistant, and since we have been attached to Evacuation Hospital No. 3, has carried on the work of the team as operator. He is a skillful and experienced surgeon, capable and of good judgment. Lieut. Paul B. Steele, the anæsthetist, but now assistant to Major Metcalf, was equally untiring in his devotion to his work and has already proved himself a capable assistant. He deserves promotion. The two nurses, Miss Mary Owens and Miss Lillian Bowen, cannot receive too much praise. They endured great physical hardships and "carried on" when utterly fatigued time and again without any thought or question of themselves. Their ability as operating team nurses is of the highest merit, and after seventeen months in France I can earnestly say that I have never seen two women better adapted to their work. The enlisted men acting as orderlies, Privates Wischman and Ward, had had no previous training; one having been a fireman on a locomotive and the other a "section hand." Both had recently arrived in France. Both rapidly fitted into their new position and one, Private Ward, became an exceptionally proficient operating room orderly. Their behavior was always correct, their devotion to the team a source of the greatest satisfaction, and their willingness to work at all times a great credit to themselves. Unfortunately, Private Ward sustained severe injuries to both hands August 12, from the bursting of a hand grenade, and after operation was evacuated to the Base.

Again, before placing the following summary before you, let me beg indulgence for the incompleteness of the report. Anyone who has been through a long service of this kind of work will realize the difficulty under so much pressure of making careful records and of obtaining any real figures on results. Further, if they are consistently busy they will have found how extremely difficult it is to correlate and summarize even the bare facts which they may have to present. In going over our records I find that what we have chiefly to present is an anatomical summary of the kind and distribution of wounds received. Careful studies are being made of some of the groups in which we are especially interested and about which we hope to make a more elaborate report later on.

A. FIRST PERIOD.—*June 18 to July 18* (this runs into the second period of military activity beginning with the Battle of the Marne, July 15, 1918).

WAR SURGERY UNDER FRONT-LINE CONDITIONS

INJURIES TO THE HEAD

Group	I. Scalp wounds	13 cases.
	(9 closed by suture, 4 partial closure.)	
Group	II. Fracture without dural penetration	5 cases.
	(3 closed by sutures, 2 partial closures.)	
Group	III. Fractures with dural penetration and depression without extrusion of brain	2 cases.
	(1 closed by sutures, 1 partial closure.)	
Group	IV. Gutter type, with brain extruding and indriven fragments of bone	1 case.
	(1 case closure by suture.)	
Group	V. Penetrating type, with indriven bone plus metal ...	1 case.
	(missile removed, closed by sutures.)	
Group	VI. Ventricles opened	0 cases.
Group	VII. Craniofacial wounds opening sinuses	1 case.
	(Partial closure, rubber tissue drain.)	
Group	VIII. Perforating wounds	0 cases.
Group	IX. Bursting fractures	1 case.
	(Closure.)	
		—
Total cases		24
Total deaths (known of)		2
(Group IV, 1; Group IX, 1.)		
Mortality, 8.6 per cent.		

Discussion.—During the first period very few “head” wounds came through to the centre in which we were working because a field hospital further up the line had been fitted with surgical equipment and teams, and was taking all non-transportable cases, among which “head” cases were included. We employed the technic initiated by Lieut. Col. Harvey Cushing, under whom we had had the opportunity of being trained in such work, and our results were satisfying. The careful preparation and method of operation under local anæsthesia were strictly adhered to even in the simplest cases. At first, with a team untrained in such work, the operations went slowly and seemed cumbersome, but with practice things went more smoothly and the results, to those who are familiar with such work, were gratifying.

The two deaths follow: (1) A gutter wound low in the left temporal region with a punctured dura and indriven bone fragments; patient developed meningitis (streptococcus) and died on the tenth day; we have felt this might have been avoided by better technic. It was the first head case done by the team.

(2) A bursting fracture with multiple cracks running from the vertex to the base. Patient was side-swiped off a truck and was admitted unconscious. A decompression was done. Patient died in four hours.

ELLIOTT C. CUTLER

INJURIES TO THE ABDOMEN

(1) Wall only	2 cases.
("Débridement.")	
(2A) Penetrating wounds, with perforation of intestines	1 case.
(Suture of multiple holes, no gut resected; closure.)	
(2B) Penetrating wounds, without perforation of intestines	1 case.
("Débridement," closure abdomen, skin not sutured.)	
	—
Total cases	4
Deaths	0

INJURIES TO THE CHEST

(1) Injuries to chest wall only: (a) Without fracture ribs	7 cases.
(b) With fracture ribs	1 case.
("Débridement," removal broken ends of bone.)	
(2) Penetrating injuries: (a) Without fracture ribs	1 case.
(b) With fracture ribs	2 cases,
("Débridement," removal broken bits of ribs. One case— foreign body removed.)	
(3) perforating wounds (with fracture ribs)	1 case.
	—
Total cases	12
Total operations (penetrating and perforating cases)	2
Deaths	0
1 case reoperated for drainage after primary closure.	

COMPOUND INJURIES CHEST, DIAPHRAGM AND ABDOMEN

1 case—Perforation of chest wall, lung and diaphragm; missile lodged in liver; no operation; recovery.

2 cases—Perforation chest wall, lung, diaphragm; missile lodged in abdominal cavity.

Operations

2

Deaths

2

(One gas infection, liver; other bowel and kidney lesion.)

All cases of injury to head, chest or abdomen were held at least seven days for observation, and all that were evacuated left the hospital in good shape.

NERVE SUTURES

Ulnar

1

External peroneal

1

BLOOD-VESSEL LESIONS

1 case—Ligation subclavian artery for traumatic injury axillary artery; transfusion; evacuated in satisfactory condition.

WAR SURGERY UNDER FRONT-LINE CONDITIONS

SOFT PART INJURIES

	Shell wounds	Rifle or machine-gun bullets
Face	15	0
Eyes	2	0
Neck	4	0
Back	13	0
Arm	33	4
Forearm	16	0
Hand	12	3
Buttock	15	0
Thigh	35	1
Leg	35	1
Knee (superficial)	4	0
Foot	8	2
	—	—
Total	192	11

Deaths—2. (See under summary of deaths.)

Discussion.—The usual operative procedure followed was to make long incisions parallel to muscle fibres, to “débride” the tract as thoroughly as possible and then to cover the wound with a piece of gauze wet in Carrel-Dakin fluid, after protecting the skin edges by strips of vaseline gauze. More rarely gutta-percha strips were laid in for drainage and to protect against painful subsequent dressings. Still less frequently Carrel-tubes were inserted, and these were not used unless it was our intention to detain the case in the hospital for several days in order to observe its future course. In the early part of this first period some primary sutures were attempted, with, so far as our observations in detained cases and from the results of returned post-cards went, good success. After July 1, 1918, this procedure was prohibited by order.

INJURIES WITH FRACTURES

(Exclusive of skull and joint injuries)

	Shell wounds	Rifle or machine-gun bullets
Spine	1	0
Pelvis	3	0
Scapula	3	0
Humerus	2	1
Forearm	3	1
Hand	6	5
Femur	2	1
Leg	10	0
Foot	7	7
	—	—
Total	37	15

Deaths—2. (See under summary of deaths.)

Discussion.—The procedure with fractures was the same as with soft parts: wide thorough “débridement” through long incisions. The operation was invariably performed with the member in extension. Small fragments of bone, unless deemed essential, were as a practice removed. The apparatus was applied immediately, and we always made it an especial point to see that it was properly applied, with good traction and the correct amount of flexion maintained where joints were concerned.

Fracture cases were more often detained in the hospital than soft part injuries, and Carrel-tubes were more often used, and in our opinion provide a decided help in combating the infection which in some cases is certain to be present, no matter how thorough the original operation.

INJURIES TO JOINTS

Knee.....	5	Penetrating shell wounds, soft part only.
	1	Perforating shell wound, with fracture.
	3	Penetrating shell wounds, with fracture.
	1	Perforating bullet wound, with fracture.
Shoulder.....	1	Penetrating shell wound, soft parts only.
	1	Perforating shell wound, with fracture.
Elbow.....	3	Perforating shell wounds, with fracture.
Wrist.....	1	Penetrating shell wound, soft parts only.
Phalangeal....	Many,	since in most of the hand and foot injuries joints were opened or blown out.
Ankle.....	2	Perforating shell wounds, with fracture.
	2	Perforating bullet wounds, with fracture.
<hr/>		
Total.....	20	cases.

Discussion.—The above group of cases have especially interested us for we have come to believe that in this branch of surgery the war has given us more advance than in any other. After an opportunity to study the surgery of joints, in a Belgian hospital, we have consistently practised the mobilization of joints as a principle in the treatment of injuries to joints. Cases thus treated have resulted satisfactorily in almost every instance. Naturally there are cases so disabling that motion cannot be employed and in certain joints its use is questionable; but always, when possible, we instituted active motion immediately following the operation. This principle was in practice chiefly applied to injuries to the knee-joint. Injuries to this joint, whether involving bone or only soft parts, were treated alike. Where the soft parts only are injured, usually cases of perforating wounds, we excised the wounds, left the synovia open, instituted motion at once, walking on the second day, and in three or four days practised secondary closure after smear and culture control of the wound flora. At first we tried motion after immediate closure of such wounds, but a synovitis always ensued and this practice was discontinued. This method gave us a physically “fit” man at the end of ten days, walking

WAR SURGERY UNDER FRONT-LINE CONDITIONS

about, with full motion in his joint, who within two weeks more should have been ready for duty. The method of immediate closure followed by immobilization cannot hope to bring a patient back into service within such a short space of time.

The more disabling type of injuries to joints, with a bony lesion, were treated on the same principle. Operations were done with scrupulous technic and through a bloodless field by use of an Esmarch bandage and tourniquet. The patella reflexion incision was only used when necessary, for this incision obviates the possibility of early motion. At the same time, if it was necessary, in order to properly see the entire field, this incision was made without compunction. For in no other field of war surgery is a complete knowledge of the course of, and the extent of, the lesion caused by the missile so essential to a successful result. The missile and all portions of the tract were in each case chiselled away freely. If the patella tendon had not been cut and if enough articular surface remained to permit of motion, the synovia was not closed and motion instituted at once. If motion was impossible the synovia and joint were closed in layers and a splint applied for immobilization.

In one case we were forced to do a resection. Because of subsequent infection this leg was later amputated. In six of the knee cases, the joint fluid showed bacteria before operation. All cases except the above resection left the hospital in good shape, and those which had been mobilized with at least a fair range of motion and an uninfected joint. Four knee-joints were closed by suture on the fourth or fifth day and went on without trouble to a satisfactory convalescence. No drainage tubing was ever used.

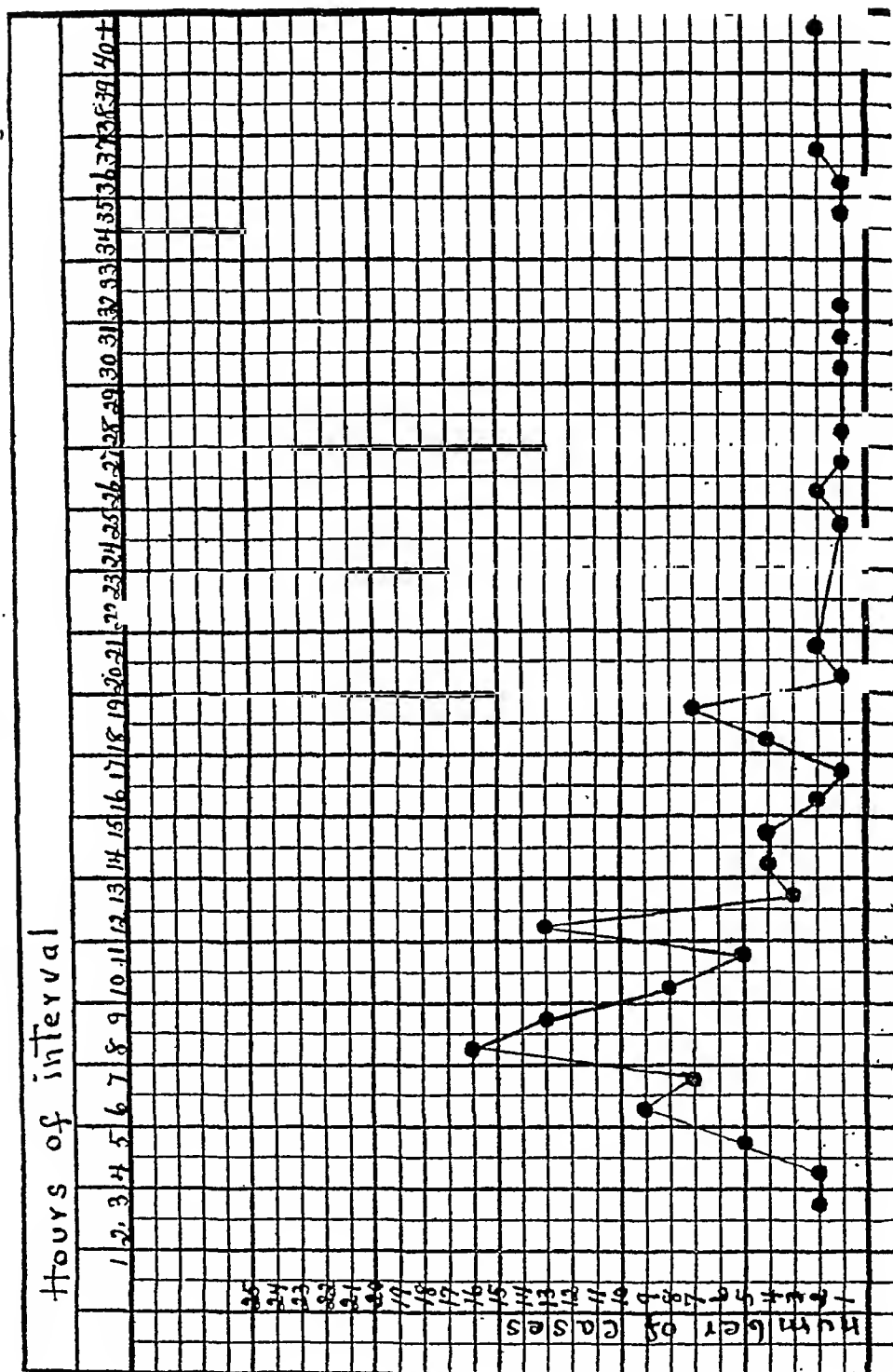
WORK OTHER THAN BATTLE CASUALTY WORK

At least ten cases of this type came under our care. There were two appendicitis cases, several carbuncles, abscesses, and infected pilo-nidal sinuses, and a case of streptococcus pleurisy, which was drained at the tail end of a very severe pneumonia and ran a long and dangerous convalescence before he could be sent down the line.

GENERAL SUMMARIES

(A) No foreign body present (gutter or through and through wounds)	127 cases.
Foreign body removed	98 cases.
Foreign body not found	19 cases.
Total	244 cases.
(B) Single injury	138 cases.
Two missile injury	36 cases.
Multiple injuries	34 cases.
No operation	35 cases.
Total	243 cases.

(C) INTERVAL IN HOURS FROM INJURY TO OPERATION



WAR SURGERY UNDER FRONT-LINE CONDITIONS

The interval of time between being wounded and operation was not always obtained. However, the chart shows graphically that the maximum number were operated upon within ten or twelve hours of the time at which they were wounded. This is certainly not a desirable interval.

(D) METHODS OF CLOSURE AND DRESSING OF WOUNDS

(a) Closure.

1. Primary closure	47
2. Partial closure with silkworm-gut drain	18
3. Partial closure with rubber tissue or gutta-percha	37

(a) Total 102

Discussion.—Of the primary closure wounds, and in this group one may include those with a few silkworm-gut strands for a drain, twenty healed uneventfully as reported by the seventh day; four were partial failures; two were complete failures. The partial closures with rubber tissue drains should not enter into a discussion of the primary suture cases. This leaves sixty-five sutured cases with twenty complete successes known of. Insufficient data forbid any deductions being drawn either way.

(b) No closure.

1. Carrell-Dakin tubes	41
2. Gauze wet in Carrell-Dakin fluid	134

(b) Total 175

Total (a) and (b) 277

(This is an aggregate of wounds, not cases. One patient with multiple wounds may require different treatment for the separate wounds.)

(E) DAILY NUMBER OF OPERATIONS (See Chart, page 704)

Total cases in first period, 260 cases. On duty during first period, 24 times. Average number of operations per tour of duty, 10.8.

RESULTS.—The account which follows is completed from evidence obtained by use of post-cards returned by the patient or personal observation. It is meagre and permits of no discussion or deductions.

(A) *At Twenty Days.*—Healed wounds, 34; improved, 37; secondary operations, 3.

(B) *Amputations.*—1. Secondary amputation right leg for infection; case originally operated at a Field Hospital.

2. Secondary amputation thigh for gas infection; five days after original operation (not originally operated by this team).

3. Secondary amputation thigh for infection following resection knee.

4. Primary amputation leg for compounded tibia, gas infection and divided posterior tibial artery (eighteen hours after injury).

5. Primary amputation thigh for gas infection involving knee-joint and leg. (German prisoner, forty hours' interval.)

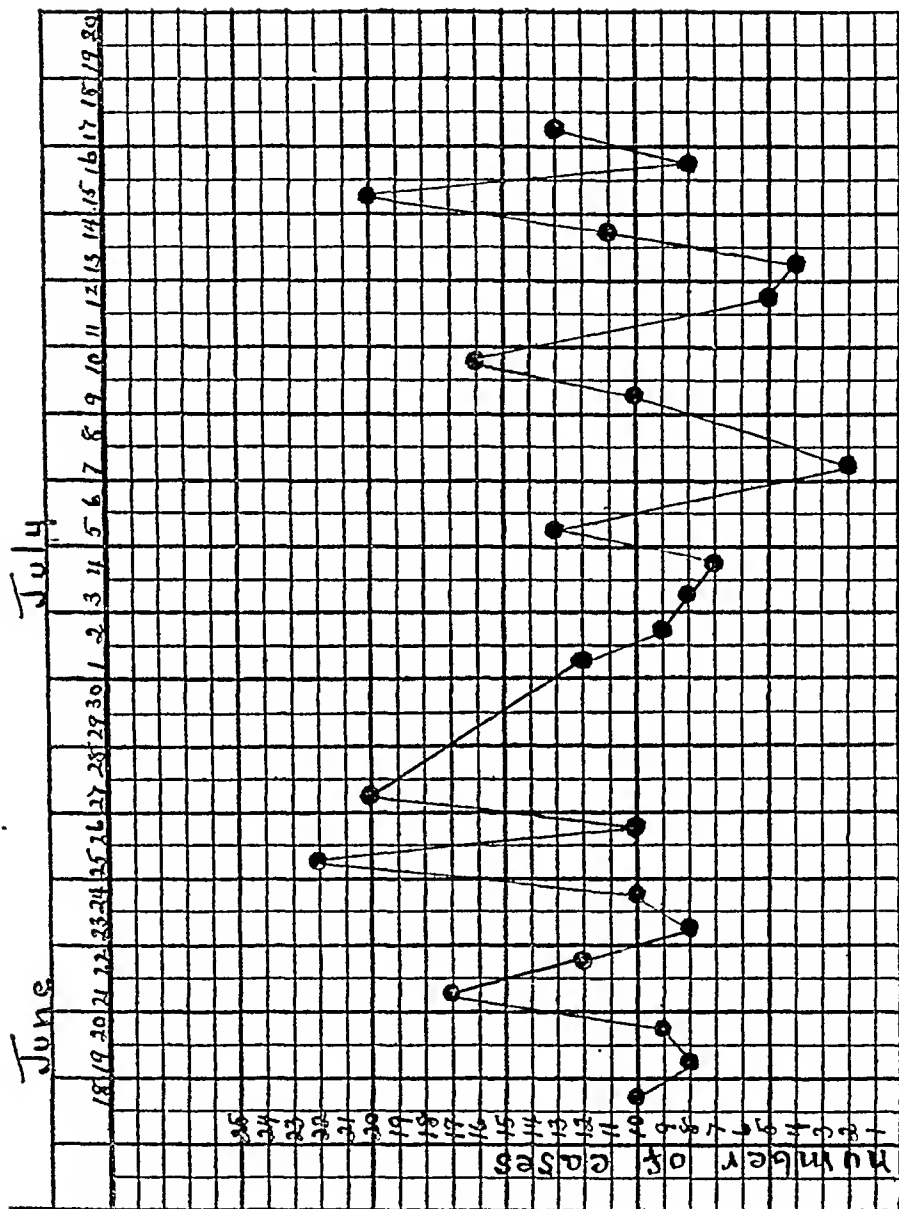
6. Primary amputation forearm; tourniquet on for fourteen hours.

7. Primary amputation thigh for gas gangrene.

8. Double amputation legs, primary, for gas gangrene.

9. Multiple amputations fingers and toes.

DAILY NUMBER OF OPERATIONS



WAR SURGERY UNDER FRONT-LINE CONDITIONS

(C) *Deaths*.—I. (F.) Fracture, compound, skull; usual operation, closure, died tenth day, meningitis.

2. (C) G. S. W., left arm and right leg; "débridement," died third day, bronchopneumonia.

3. (B) Superficial wound, shoulder; badly gassed. Died tenth day, pneumonia and severe mustard burns.

4. (K) Fracture compound, skull; bursting type, basal fracture, accidental, decompression. Died in four hours.

5. (H) Multiple wounds, face, scalp, lower arm and forearm, groin, scrotum, left thigh and leg, sucking chest wound perforating diaphragm to abdomen. Chest, diaphragm, abdomen operation. Died in four hours. Foreign body found in kidney.

6. (W) G. S. W., multiple, both legs; amputation left, incision and drainage right; shock. Died in two days.

7. (A) G. S. W., chest; chest-diaphragm, liver operation; gas infection. Died second day. Jaundiced before operation.

8. (W) G. S. W., both legs; double amputation for advanced gas infection. Died in ten hours.

Mortality.—Eight deaths in 260 cases—3.07 per cent.

B. SECOND PERIOD.—*Summary.*—July 18 to August 8, 1918 (the second Battle of the Marne).

INJURIES TO THE HEAD.

Group	Number of cases	Primary closures	Closures with small gutta-percha drain
I	13	13	0
II	5	2	3
III	1	1	0
IV	3	1	2
V	6	3	3
VI	3	0	3
VII	4	0	4
VIII	2	0	2
IX	0	0	0
	Total. .37		

Deaths.....	4	{ Basal fracture without wound.....	1 case.
		{ Group VI.....	2 cases.
		{ Group VIII.....	1 case.
Mortality	10.8 per cent.		

Discussion.—The same technic was employed as in the first series. The lesions in this series were of a far more serious nature, and, indeed, about six cases were brought to the table moribund and inoperable. These have not been placed on this list; also several cases partially operated at field hospitals further up the line were brought to our care in a serious condition. In only one of these cases was a further operation adjudged advisable and this proved fruitless.

This may not be the appropriate place for this expression of opinion, but we feel forced to say this of head cases: Unless a surgeon thoroughly familiar with this field of surgery is available in the most forward areas, it would seem to us advisable to transport such cases further back where men trained in this field may be found. Head cases stand transportation

infinitely better before operation than after it. Also, when such cases are operated we believe that the entire operation should be done and no half-way measures permitted. Failure, chiefly due to infection, has invariably followed any attempt at half-way measures. This may mean the necessity of very long transportation before operation. Even so, we think that would be safer than partial operation, or operation by untrained hands.

INJURIES TO THE ABDOMEN

1. Wall only, without lesion of peritoneum	5 cases.
2. Penetrating wound, with perforation of intestines	4 cases.
<hr/>	
Total	9 cases.
Deaths	1 case.

Discussion.—Of the latter group (2), one died in two hours; missile had fractured femur and passed upwards, literally tearing the bowels to pieces; should not have been opened, and was closed without any attempt to repair. The other cases, after repair of multiple lesions, made a successful convalescence until evacuated. One case was drained for pelvic peritonitis, but progressed favorably from the beginning; the other cases were closed without drainage. One case in which there had been an extensive laceration of the liver was reopened and the abdomen emptied of at least one liter of almost pure bile; convalescence uneventful and successful without any further intervention.

INJURIES TO THE CHEST

1. Injury to chest wall without fracture of rib and without penetration to pleural cavity. (In some the pleura was torn.)	10 cases.
2. Perforating wounds without fracture ribs	7 cases.
3. Penetrating wounds: (a) with fracture ribs	3 cases.
(b) without fracture ribs.....	9 cases.
Total	29 cases.
Deaths	None known of.

Discussion.—Of the nineteen perforating and penetrating cases, only three cases were operated, *viz.*, two of the cases with fractured ribs and one with a large and easily available foreign body. Experience made us more and more convinced that a majority of the lung cases do better without immediate exploration.

Compound Injuries to Chest, Diaphragm and Abdomen.—One case, which perforated, emerging close to spine, no operation at first, later with increasing distention and vomiting; abdomen opened, great quantity of bile, free of bacteria, drained away; recovery.

Nerve Sutures.—Ulnar, 2; median, 1; sciatic, 1; musculospiral, 1.

Blood-vessel Lesions.—1. Traumatic division axillary artery—ligation third portion subclavian under novocaine; died third day, gas infection.

2. Traumatic division femoral artery, fracture femur, gas infection—amputation.

WAR SURGERY UNDER FRONT-LINE CONDITIONS

3. Traumatic division occipital artery—tied vessel in wound after “débridement.”

4. Traumatic division posterior tibial artery, G.S.W. with fracture fibula, tourniquet in place; apparent return of circulation after removal tourniquet—ligature, “débridement;” on second day amputation for gas infection.

5. Traumatic division axillary artery and vein—ligatured, O.K., when evacuated second day following operation.

WOUNDS WITH INJURIES TO SOFT PARTS

	Shell wounds	Bullet wounds
Face	14	1
Eyes	2	0
Neck	2	2
Shoulder	11	3
Arm	10	7
Forearm	3	5
Hand	7	8
Buttocks	11	8
Thigh	24	10
Scrotum and pelvis	1	1
Leg	26	2
Foot	8	4
Back	5	4
	<hr/>	<hr/>
Total	125	55

Discussion.—The same technic of wide incision and thorough “débridement” used in the first period was adhered to. But in this period, because of increased experience, our work was probably of a much better kind and certainly we were more facile.

INJURIES WITH FRACTURES

(Exclusive of Skull and Joint Lesions.)

	Shell wounds	Bullet wounds
Face	3	3
Shoulder girdle	5	1
Arm (humerus)	8	3
Forearm	1	0
Hand	3	0
Femur	5	4
Leg	5	4
Foot	1	1
Spine	2	3
	<hr/>	<hr/>
Total	33	19

Discussion.—Again we followed the same technic of operation and dressings used in the first period, even greater care being devoted to correct and adequate splinting. And with increased experience we remained fully as conservative insofar as amputation is concerned.

INJURIES TO JOINTS

Knee	{	2 Penetrating S. W. soft parts only.
		3 Perforating S. W. soft parts only.
		3 Penetrating S. W. with fractures.
		3 Penetrating S. W. with fractures.
		2 Perforating bullet wounds, soft parts only.
Shoulder	{	1 Penetrating S. W. soft parts only.
		1 Perforating S. W. with fracture.
Elbow	{	2 Perforating S. W. soft parts only.
		1 Perforating S. W. with fracture.
		1 Perforating S. W. with fracture.
Total		19 cases.

Discussion.—See under first series; it was so difficult to detain my cases this period that the treatment of joints became most unsatisfactory. Mobilization was instituted and full notes sent along with each case advising that this method be continued. Also, each patient was impressed with the importance of this procedure.

GENERAL SUMMARIES

(A) No foreign body present (gutter or perforating wounds) ..	138 cases.
Foreign body removed	74 cases.
Foreign body not found	5 cases.

Total 217 cases.

(B) Single missile injury	143 cases.
Two missile injury	25 cases.
Multiple missile injury	38 cases.

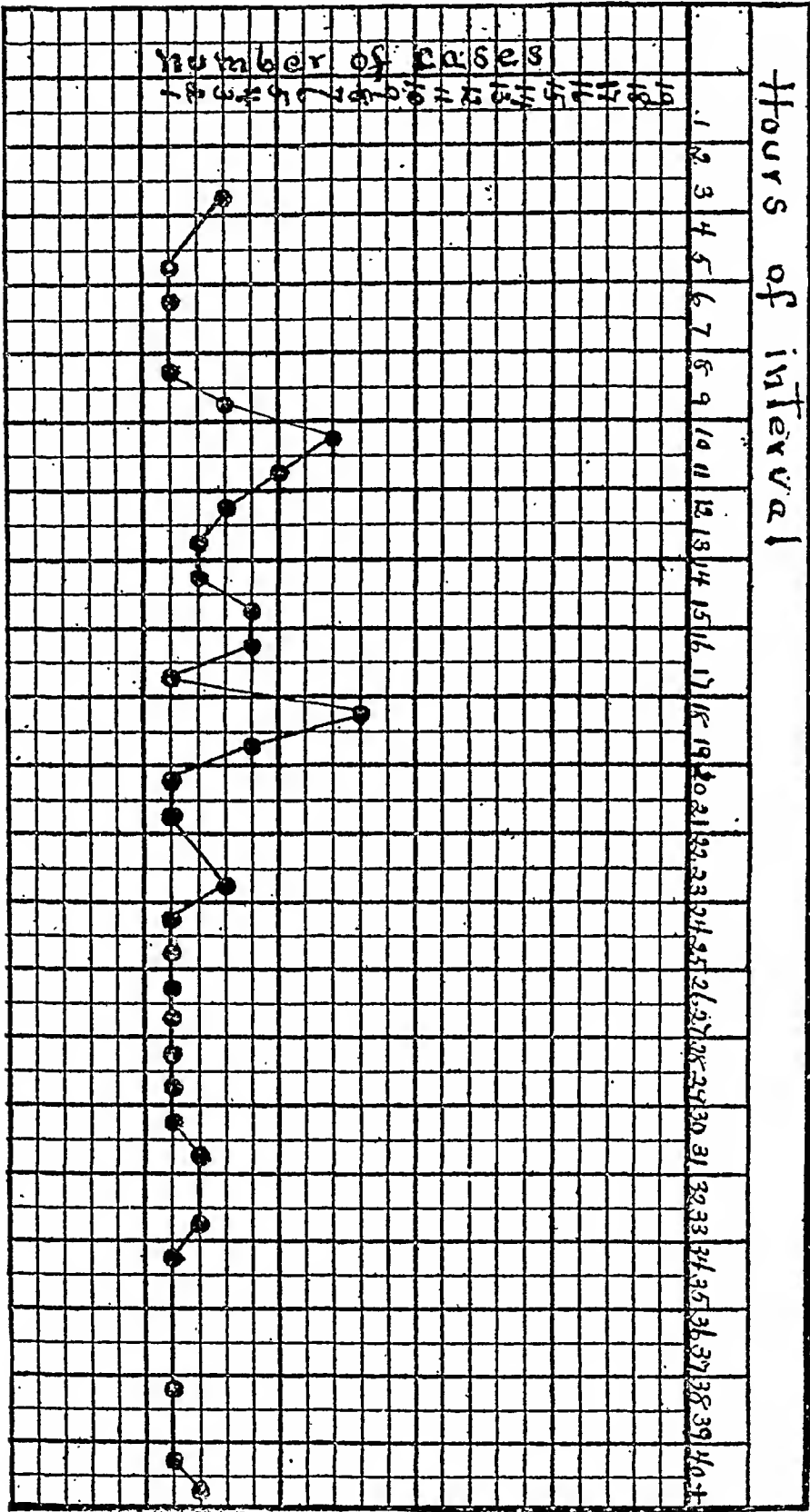
Total 206 cases.

(C) INTERVAL IN HOURS FROM INJURY TO OPERATION (SEE CHART, PAGE 709).

The interval of time between being wounded and operated was obtained in only a minority of the cases. Throughout this period our records are in places very fragmentary, so great was the pressure of work. But it is certain that the interval before surgical treatment was given became very extended; probably fifteen hours would be a low average. With the beginning of the Marne battle this was due to the fact that the number of cases admitted to the two hospitals at Coulemmiers was excessive and then later in the battle transportation became difficult, was insufficient, and the distance became very great.

WAR SURGERY UNDER FRONT-LINE CONDITIONS

INTERVAL IN HOURS FROM INJURY TO OPERATION



ELLIOTT C. CUTLER

(D) METHODS OF CLOSURE AND DRESSING OF WOUNDS

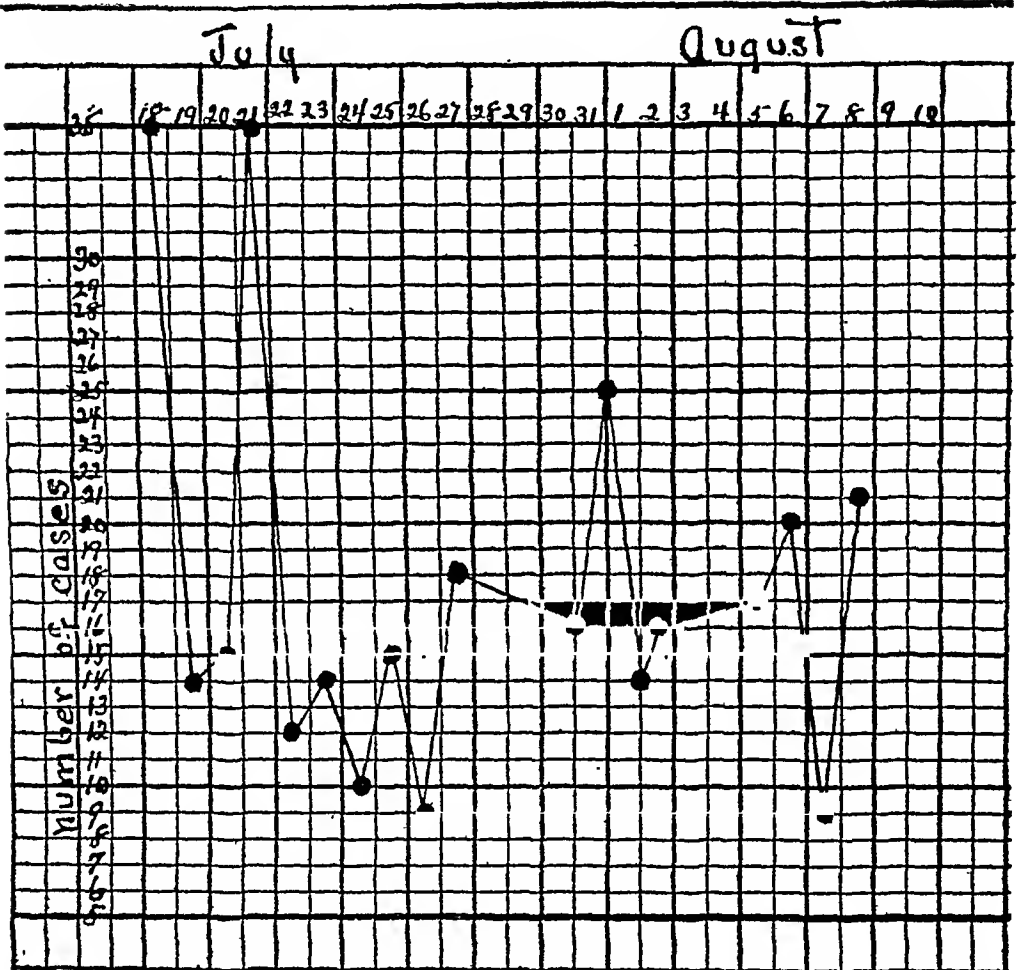
(a) Closure:

1. Primary closure 1 case.
2. Partial closure with small gutta-percha tissue drain.. 9 cases.

(b) No closure:

1. Carrell-Dakin tubes 12 cases.
2. Gauze wet in Carrell-Dakin fluid 161 cases.

(E) DAILY NUMBER OF OPERATIONS



Where the daily number of operations is high, as in the two days of 35 cases, we were on duty 18 hours or more, and there were several cases requiring dressing only.

Total cases in second period 316 cases.

On duty during second period 18 times.

Average number of operations per tour of duty 17.5.

Results.—The data are almost entirely lacking. We were pushed always to the limit of our endurance, and scarcely saw cases more than once, if even that, after they left the table, and many cases left their post-cards behind or lost them on their way down the line.

No operations: (Dressed) 47 cases,

Amputations.—1. T—Secondary amputation thigh for gas infection.

2. P—Primary amputation thigh for gas infection; fracture of femur and divided femoral artery.

3. K—Primary amputation leg for gas gangrene; three days since injury (German prisoner).

4. McH—Secondary amputation thigh for gas gangrene.

5. Multiple amputations fingers and toes, numerous.

Deaths—1. McH—Fracture compound skull, penetrating wound to the ventricles.

2. D—Fracture compound comminuted femur and humerus, in shock; cleaned up as much as condition permitted; died in twenty-four hours of gas infection, leg.

3. C—Lesion dividing axillary artery and vein; large foreign body in neck; patient in shock, gas infection; under novocaine foreign body removed and tissues widely opened and subclavian artery tied; died three days later, gas infection.

4. T—Fracture compound comminuted femur and multiple perforation intestines; abdomen opened, closed without repair; died in two hours.

5. C—In shock, shell wound hip and leg; foreign body removed from hip and leg; widely opened; died in twenty-four hours, gas infection.

6. A—Shell wound, chest, entry anteriorly, sucking wound; foreign body in spinal muscles; anterior wound closed; foreign body removed, posterior drainage tubes into chest established at this point; died thirty-six hours, pneumonia.

7. C—Shell wound neck and arm, bulbar paralysis; no operation; died in twenty-four hours of pneumonia.

8. R—Shell wound hip, fracture compound comminuted femur; "débridement," two sutures, Carrel-Dakin tubes, Thomas splint; evacuated under pressure; died some days later at the base hospital. (Report streptococcus septicæmia.)

9. T—Fracture compound skull, penetrating to ventricle, gas infection; foreign body removed at operation and drain inserted—died.

10. N—Fracture compound skull, perforating postparietal region; died meningitis three days.

11. Fracture compound skull, moribund, dressed; died in an hour.

Mortality.—Eleven deaths in 310 cases—3.54 per cent.

General Summary.—The above review is a brief survey of the work done. Its incompleteness makes one uncomfortable, as it may seem an indication of careless work, and yet we think we always attempted to be thorough, careful, conservative, and to treat each case individually and to the best of our ability and experience.

Certain procedures have now become established in our minds and possibly our deductions may be of interest:

Head Cases.—In this field there is little to add to the preceding discussion following the enumeration of the cases done, and nothing at all to

the brilliant contribution on this subject of Lieut. Col. Harvey Cushing, M. C., whose work is widely known and available to all.

Chest Cases.—With experience we have become more and more conservative and now would only operate on cases with injury to the chest for the following conditions: (1) Sucking wounds; (2) the compound chest-diaphragm-abdomen lesions; (3) large and easily available intra-thoracic missiles; (4) non-penetrating wounds or perforating wounds with much bony destruction.

For the other types of injury to the chest we have established the following routine: Rest in bed and the sitting posture, morphia, strapping to limit motion of the afflicted side if advisable, observation. If no indication (sepsis) hastens action, aspiration on the third, fourth or fifth days. This is done irrespective of retained missile or perforating wounds. If infected fluid is found and a foreign body is present, and the general condition worse, the patient is re-X-rayed and then drained under local anæsthesia. Often, if a foreign body is superficially located in the lung it may have formed an abscess and then dropped to the bottom of the pleural cavity, in which case it can be removed. If a foreign body is present and the infective agent not of a violent nature, and the patient's condition good, operation is deferred, and in many cases the infection has been taken care of and the patient recovered without operation.

Chest-diaphragm-abdomen Cases.—These cases, also, do not always require operation. This depends greatly on the size and kind of missile. Small shell fragments and bullets reaching the liver through a lung and diaphragm may allow recovery with a minimum of trouble and without operation. The larger missiles require operation as soon as possible and should be done as near the front line as possible. We believe in opening the chest first, sewing up the diaphragm if the missile has perforated to the liver, and lastly doing the abdominal part of the operation. If the missile is in the liver and infection present, it may be necessary to sew up the diaphragm to the chest wall and drain direct into the liver. Such cases do badly.

Injuries to soft parts and those with fractures are treated alike by wide incision and thorough "débridement." Adequate and correctly applied apparatus is essential in the fracture class of cases, and by experience we have come to be firm believers that primary sutures, except in the following exceptional groups of cases (heads, chests, abdomens, joints and nerves), should not be allowed in evacuation or other front line hospitals.

Injuries to Joints.—We have discussed this class of injury at length following the enumeration of the cases in this report and can only repeat our firm adherence to the principle of mobilization in the treatment of injuries to joints and lay especial emphasis on this method in the case of injuries to the knee-joint.

POST-OPERATIVE SUPPURATIVE PAROTITIS *

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History of Case.—Mrs. D., aged thirty-four years, American, no familial history of neoplastic disease, dyscrasia or tuberculosis. Of the infections during childhood she had measles, chicken-pox, and mumps of both parotids. Three years ago had whooping cough—duration twelve weeks. Menstruated at thirteen, duration eight days, dysmenorrhœa, very irregular to twenty, irregularity represented by intermittent and vicarious nasal bleeding associated with pelvic distress and pain. Married at twenty-one, three para, first instrumental, nursed all children full time; no pelvic or mammary infection.

In October, 1918, had a severe attack of "Flu;" confined to bed five weeks, and never fully recovered from its effects. It was represented by general myalgia, severe headache, chills, fever, bronchitis, general abdominal pain, and much prostration. Associated with the above symptoms the following is significant; pain and stiffness in the lower jaw articulations, dry mouth, swollen brown tongue with no salivary secretion. This continued for two days and was followed with much excretion of sour saliva, the secretion of which lasted eight or nine days. There was not noted any parotid enlargement. Menstruation delayed three months was reestablished in January, the flow lasting five days with associated severe lumbar pain lasting two weeks. Prior to admission to hospital she was vomiting daily all food, and suffered from general abdominal distress with severe pain in right lower quadrant and hip.

Laboratory report on admission to hospital, February 22, 1919, shows the following: Blood, red, 4,500,000; white, 10,600; hæmoglobin, 85 per cent.; fæces negative for blood and parasites; urine, negative, but large amount of bacteria; temperature, pulse and respiration normal during the five days of observation. With rest in bed and continuous enteroclysis, pain subsided and vomiting ceased. Pre-operative diagnosis of pregnancy with an adherent cystic ovary was confirmed by operation February 27, 1919, at St. Vincent's Hospital. Preliminary hypodermic of morphine $\frac{1}{4}$, atropine $\frac{1}{150}$, administered one hour before operation.

Operation.—Under ether anæsthesia on opening the abdomen an ovarian cyst was liberated from its attachment in the right lower abdominal quadrant; further examination proved it to be the left ovary with torsion of its pedicle. Salpingo-oöphorectomy and appendectomy were performed.

The cyst, cocoanut size, had a fairly thick wall enclosing a white, somewhat gelatinous fluid, which was free from bacterial invasion.

* Read before the Academy of Medicine of Toledo and Lucas County, October 17, 1919.

The appendix was involved in the circumscribed peritonitis and presented evidence of chronic inflammation. The body of the uterus was soft and equivalent in size to a six weeks' pregnancy.

The incision was closed with chromic catgut and silkworm gut. Primary union occurred, and at no time was there any further disturbance or reaction from the operative intervention.

On the second day following stiffness of the jaw with swelling of right parotid developed. This gradually increased in size and on the sixth day of involvement of the gland free incision disclosed a beginning suppurative parotitis. White count, 21,400, pus shows clear culture of staphylococcus aureus. The discharge of pus became very profuse on the ninth day and so continued for seven days, gradually subsiding on the thirty-fifth day when healing occurred. Discharged from hospital April 13, 1919, without any salivary fistula. On the eighteenth day of gland infection smear shows but few staphylococci; reds, 3,800,000; whites, 8400; hæmoglobin, 75 per cent.

During the progress of the suppuration the patient's condition was critical. The systemic reaction was characteristic of a high grade of sepsis with meningeal disturbances. Tense and stiff, the muscles of the side of face and head with drooping of eyelid associated with dysphagia continued for six weeks, and at present writing complete restoration of muscle and nerve function has occurred.

October 20, 1919, she was delivered by Dr. W. W. Brand of a nine and one-half pound living male infant. He reports early rupture of membranes forty-six hours preceding labor. That labor was delayed due to atresia of cervix from previous laceration.

The cervix normally dilated, secondary inertia, foetal heart sounds weaker, median forceps delivery, cord wrapped around neck, hemorrhagic circular infarct of placenta three inches in diameter. Present writing mother and child doing well.

Le Dentu¹ says: In suppurative forms of parotitis consecutive to operations early incision is recommended. In fact, the revealing of the suppuration ought not be awaited. Gangrene develops rapidly, which is easily explained by the fact that the gland is constricted and compressed in all parts, and owing to the nature of the infecting microbes. Incise early and widely, avoiding injury and the principal branches of the facial nerve. If the tumefaction appears to be posterior, a long posterior vertical incision is recommended; but two or three large horizontal incisions are to be preferred in practice, a little divergent in front; these suffice when the swelling is principally manifested behind the ascending branch of the lower maxillary. Whatever incision is adopted when the aponeurosis is reached the bistoury ought to be abandoned, a Nelaton cannulated sound substituted, and the gland isolated at depth with this instrument. Generally at first only sanguinous serum flows. The remission is not immediate; it only occurs when the suppuration is free, when the most profound layers are opened to the exterior and the tissues affected by gangrene are eliminated.

Although in a general way the prognosis of this unfortunate complication is in accordance with the more or less grave condition of the affection, it is certain that the progress can be checked if the principle of early and wide operation which is the basis of the treatment is put into practice.

The microbes obtained from cultures in the author's case were a golden staphylococcus and a streptococcus, the aërobian cultures of which showed a somewhat peculiar aspect.

Morestin² did a colpotomy on a woman aged thirty-three years for a pelvic suppuration. Some days later the patient showed parotitis which became fluctuant. Yellowish pus was expressed from Stenon's duct on pressure. This "expression of the duct" was continued daily and the case ultimately recovered. He reported the case as an example that even in such a severe case operative interference was unnecessary. This paper gave rise to a very extensive discussion in the *Société de chirurgie*.

Delbet thought that the whole gland, not alone Stenon's duct, would be expressed.

Tuffier thought the parotitis not especially due to abdominal operation, but that it could follow other operations, in which *chloroform* was the anæsthetic. It is very rarely that these canalicular cases finish by suppuration and he has only seen two such cases.

Quénu also observed two suppurative cases. One of these was an urgent operation done while the patient was suffering from adenoids, the other patient had a dental affection when operated.

In closing the debate Morestin stated that when incision was necessary it should be below the ear, in the posterior and inferior parts of the gland towards the submaxillary region.

Picqué³ says that in spite of the many researches which had been made to show why an ascending infection can take place in Stenon's duct, yet the last word had not been said on the exact method of the condition.

Picqué pointed out that when suppuration occurs it results with rapidity and habitually within thirty-six hours of the infection; or there may be a total or partial gangrene of the gland combined with suppuration. The microbes met are the streptococcus, the staphylococcus and certain saprogenous associated microbes.

In the true parotitis Picqué has always remarked, contrary to views of others, that nothing from the clinical viewpoint allows any differentiation, at least in the beginning, between gangrenous and suppurative and other types. Incision alone enables diagnosis to be made. The gangrenous types have always appeared fatal to Picqué. He never allows a parotitis to evolve spontaneously. In a total of 7200 operations, he observed only two cases of post-operative parotitis in cases which were infected (acute appendicitis and extra-uterine pregnancy with infection). In both cases the affection was cured by early operation.

Buscarlet⁴ illustrates a case and thinks that very severe post-operative parotites are only local manifestations of a general infection.

Lenoir⁵ says: If exploration reveals an appreciable fluctuating collection, or if anything should suggest the thought of a gangrenous evolution (and this is sometimes produced very rapidly in the case of cachectic patients) it is necessary to incise without delay. Unfortunately there are no symptoms which enable us to foresee the beginning of this complication; but it will be well to keep in mind this possible evolution of such post-operative parotitis. Picqué has declared that he never abandons this complication to a spontaneous evolution.

Gary⁶ says: Very often post-operative parotitis evolves towards suppuration. Suppuration is not always easy to recognize. Palpation gives an obscure feeling; a daily minute examination of the outlet of Stenon's duct is necessary, whence issues the droplet of pus which fixes the diagnosis.

In fortunate cases evacuation will be by the natural routes. But it is not unusual to see the fibrous resistant casing of the gland rupture through the teguments, sometimes creating a persisting salivary fistula; or even the more formidable eventuality, *i.e.*, abnormal passages from the extern auriculation, or which fuse towards the supra-clavicular region through the sheath of the sterno-mastoid, or even in the mediastinum following the sheath of the vessels.

Retropharyngeal abscesses have been formed in the aponeurosis of the parotid site.

Suppuration may end in gangrene. The violet skin becomes sphacelous, allowing multiple gas bullæ to escape as well as sanious fluid of infected odor. Phlebitis and thromboses may result. The vessels may ulcerate, cause heavy hemorrhages, necessitating ligature of the extern carotid, or leading to death. A case reported by Richel necessitated ligature. In a case reported by Gillette death resulted.

The gangrenous form which is much less frequent in the post-operative parotitis than in the parotitis of severe infections is almost always fatal. The patient, in stupor and adynamia, succumbs to pyohæmia.

Wagner⁷ states that post-operative parotitis ends in death in 30 per cent. of the cases. Legueu, who lost a patient from parotitis, in spite of large and early operation, protested in 1907 against the tendency to consider this complication as benignant, and declares that he is always very anxious when he sees it develop.

In cases when the treatment is by incision the surgeon must not count upon finding fluctuation. Owing to the very close texture of the parotid the pus infiltrates into the glandular tissues, creates little multiple pockets and only exceptionally collects. A single incision sometimes is sufficient, but often multiple incisions are necessary. By making the incision as retrograde as possible and towards the sterno-mastoid, the scar will be less visible and injury to the facial nerve will be avoided. After section of the skin the bistoury should be replaced by the cannulated sound.

POST-OPERATIVE SUPPURATIVE PAROTITIS

Bachrach⁸ describes a case of suppurative parotitis after a jejunostomy. This patient died from anæmia, and autopsy showed the local wound absolutely uninfected. There was hence no question of a spreading of infection through the lymph or blood. Diplococci were obtained from the pus of the parotid abscess which was incised.

The route of infection must be oral. It is due to the hunger treatment and rectal feeding and disturbance in the secreting glandular apparatus of the mouth.

Hanau⁹ and Pilliet¹⁰ first suggested in 1889 that parotitis could occur as secondary infection of Stenon's duct by mouth organisms. The inflammatory process begins in the centre of each lobule and spreads later to its periphery and perilobular tissues and blood-vessels. It is an ascending infection.

Girode¹¹ found cultures from the parotid infected gland, Stenon's ducts, and the oral cavity to be identical. In embolic parotitis due to pyæmia the microbes are identical with those of the primary disease.

Clause and Duplay¹² showed that infection of the parotid occurs in abnormally predisposing conditions, one of which is that the general vitality is depressed by hunger or other methods, or when the normal parotid secretion is altered.

Josephson¹³ in analyzing literature of post-operative parotitis comments on the undoubted connection between the salivary and the genital glands, at least in the line of inhibiting secretion. This renders the inhibited gland less resistant. The sudden removal of this functioning ovarian tissue may upset the balance in the internal secretions, the salivary glands suffering particularly and parotitis follows.

Frank¹⁴ in reporting two cases following appendicitis, one fatal, reviews the existing theories and concludes that its origin is due to an ascending infection of Stenon's duct; advises prophylaxis and early incision.

Blair¹⁵ discusses two theories: (1) metastatic, (2) ascending infection of the excretory duct, neither of which is above dispute. He points out the similarity of infections of salivary and biliary ducts and that stone irritation and obstruction are productive of intermittent enlargements of the glands, and that subacute or chronic inflammation without stone is not common. He reports seven cases, two mild, which recovered following incision and drainage. Five were severe infections, three recovered, and two died of general sepsis.

Collins¹⁶ reports eight cases of post-operative parotitis with four deaths and concludes that it is more apt to occur after abdominal operation, its development is favored by dry mouth, the infection ascends through Stenon's duct, advocates prophylactic oral asepsis, hypodermoclysis, and lemon candy to excite the salivary secretions and after the third or fourth day by free incision.

Deaver¹⁷ classifies post-operative parotitis into three groups: metastatic, occurring only in pyæmic condition; ascending parotitis, due to

ascending infection via the excretory ducts; and traumatic, the result either of direct pressure on the parotid gland or the forcible manipulation of the jaw by the anæsthetist during operation.

Manton,¹⁸ commenting on a fatal case of suppurative parotitis following induced abortion, says: Two sources of gland involvement, first general or metastatic, second, local, either through the lymphatic glands or ascending infection through Stenon's duct. There were no pelvic symptoms developed before the nineteenth day when general infection was well established; but the patient's mouth was foul from the beginning and he concludes the gland involvement was of oral rather than of pelvic origin.

Fortunately post-operative suppurative parotitis is a rarity. But few cases or none are allotted in the life work of the surgeon as an individual. Collectively there have been many reported cases.

While my remarks are directed to the consideration of suppuration of gland, much can be applied to the phenomena of the ordinary infective parotitis. The gland is subject to the mild types of inflammation in varying degree to the more severe pathology of suppuration and gangrene. In presenting the following abstracts and reports of cases, attention is directed to the diversity of opinions regarding this subject. It is the purpose of this paper, by comparison of the various theories, a critical review of case reports, and my own personal experience, to enunciate certain principles in the hope to dispel many of the debatable points and to bring the subject in somewhat of a logical state.

During a surgical service of thirty years the writer has had under observation some twenty cases of infective parotitis, post-operative. One fatal suppurative case occurring during the fifth day of pneumonia was seen in consultation fifteen years ago. The abscess was not drained, the patient dying a few hours later. In my experience the type of operation itself had but little direct influence on the parotitis, for it followed in one case from amputation of hip, in another from herniotomy. Neither from the anæsthesia, for it developed in the earlier days when chloroform was used exclusively, also during ether anæsthesia, also nitrous oxide and oxygen anæsthesia, and also local anæsthesia.

Preliminary hypodermics administered one hour before operation, morphine when chloroform was administered, morphine and atropine for ether, H.M.C. for nitrous oxide and oxygen, and morphine for local anæsthesia; these facts are not impressive in their relation to parotitis as causative factors.

The season of the year has made no appreciable difference in the infection, occurring at any time with equal severity.

Bertelsen¹⁹ reports from Umanak, Greenland, that epidemic parotitis was introduced in 1913; that over one-half of the population was affected and that fifty per cent. of the nursing women had mastitis. That there was one suppurative mastitis and one suppurative parotitis.

Inquiries among industrial surgeons concerning suppurative parotitis following injuries of the soft structures of the face or fractures of the maxillaries elicited a negative response. Even in the presence of extensive suppuration and foul mouths infective parotitis did not develop. The prize fighter deletes his opponent with a mandibular blow on the masseteric tuberosity which disturbs the circulatory equilibrium of the semi-circular canal and at the impact the parotid must receive some injury. The results of such injuries have been negligible as to infective parotitis. A consideration of the lymph channels of the face reveals the important fact that the only afferent chain to the parotid lymph-nodes drains the temporal region, while the oral and pharyngeal glands empty into the deep cervical. The anterior auricular nodes are small, three or four in number. Their location is superficial, anterior to the ear, upon the parotid gland, and they drain the temporal region, their efferents passing either to the superficial, cervical or the submaxillary nodes. The parotid nodes are imbedded in the substance of the parotid gland and receive lymph from the gland and also from the eyelids and the external ear. Their afferents pass to the superficial cervical or superior deep cervical nodes. The deep facial nodes are situated upon the buccinator muscle and on the lateral wall of the pharynx. They drain the deep lymph vessels of the face (orbit, nasal cavity, palate, etc.) and come into relation with the superior deep cervical nodes, there being no distinct line of separation between the two groups.

These anatomical facts definitely eliminate the transmission of infection to the parotid through the lymph channels of the mouth, unless we consider the question of retrograde embolism, which is hardly feasible, as the clinical signs are lacking.

The pyogenic micrococci that are found in suppurative parotitis are the staphylococcus, streptococcus, and pneumococcus. The characteristic attribute of the staphylococcus which is most frequently found in suppurative parotitis is that having gained an entrance into susceptible tissue it at first produces a local infection or spreads to surrounding structures from which general distribution through the blood stream occurs. Evidence is lacking that there is a primary circumscribed inflammatory reaction of buccal tissues. Notations show the orifice of Stenon's duct but slightly involved, though pus exudes in quantities. The streptococcus grows on mucous surfaces and penetrates into the tissues, producing inflammation, more rarely concentrated in abscess formation. Invading the lymphatics, they are carried into the blood stream producing general bacteriæmia, or attacking the blood-vessels, producing infected thrombi, from which they are continually shed into the circulating blood. During the course of a pneumonia, especially of the more severe types, the pneumococcus may gain access to the general blood stream and produce pneumococcus septicæmia. It is during the acme of this bacteriæmia that parotid suppuration ensues.

Fenwick,²⁰ in an article entitled "The Prevention of Parotitis During Rectal Feeding," believes the infection ascends Stenon's duct. He advises the use of a rubber teat for hours to stimulate the flow of saliva. This procedure with rectal alimentation prevented parotitis in more than three hundred cases of hæmatemesis.

Rolleston and Oliver²¹ in the medical treatment of one thousand cases of gastric ulcer conclude that secondary parotitis may complicate gastric ulcer by oral starvation; it occurs ten and one-half times more frequently than in cases allowed fluid by mouth; that it is an outcome of the dry condition of the mouth; that mouth washes are preventive; that suppuration occurs in about one-fourth of the cases.

Moreau²² reports two cases of suppuration of parotid following severe malarial fever. He emphasizes the necessity of oral asepsis supplying the organism with water, and concludes that dehydration favors ascending infection in the mouth.

At this juncture it would be well to consider the general character of bacterial infections.

MacCallum²³ writes: "Virulent bacteria in a person whose resistance is low may, however, grow rapidly and be quickly transported to other parts of the body by the lymphatic channels, or even in some cases by the blood stream. If an intestinal loop is ruptured, pouring great quantities of infected material into the peritoneum, the bacteria are taken into the lymphatics of the diaphragm, and hence through the mediastinal lymph channels to the retro-sternal lymph-glands with the greatest celerity, and after a very few minutes may be found in the circulating blood.

Bacteria alone introduced into the tissues or body cavities are relatively easily killed. If, however, foreign bodies or dead tissue are present there, to afford a shelter against the disinfecting action of the tissue juices until multiplication to great numbers has occurred, the bacteria can more readily gain a dominating position. Bacteria in the uterine cavity in the puerperal state may be practically harmless were it not for the protected culture-medium offered by remains of detached and dead placenta, in which they reinforce themselves by growth until they can victoriously invade the uterine wall."

The effects of the late epidemic of "Flu" in the following case are illustrative and significant. In a personal communication Mannhardt reports a female, aged thirteen, affected with the respiratory type lasting five days, infective parotitis ensued for five days. During the progress double ovarities developed; this was followed in a few days by severe epigastric pain and vomiting with jaundice. Palpation over pancreatic area elicited much acute pain and tenderness. Convalescence was protracted. The following month menstruation was established, since which time she has been regular, duration five days, no associated pain. Preceding the menses one week she suffers with jaundice and an eczema of palms of both

hands. Both disappear when menstruation ceases. These phenomena have continued for past seven months.

From the foregoing we are forced to conclude that our theories and views of the origin of the involvement of the parotid are erroneous, for they cannot be sustained by well proven facts of bacteriology, anatomy, or pathology.

In seeking for a logical solution of parotitis let us consider briefly the physiology and bio-chemistry of the gland.

Macleod:²⁴ "Control through the nervous system is most marked—indeed, it may be the only means of control—in glands which have to produce their secretion promptly, whereas hormone control predominates in those in which prompt changes in secretory activity are not required. Thus, nervous control alone is present in the salivary glands, whereas hormone control is predominant in the pancreas, intestinal glands and liver."

The parotid nerves are derived (a) from the auriculo-temporal, (b) from the sympathetic on the exterior carotid. The fibres of the sympathetic are vaso-constrictor. Those of the auriculo-temporal convey to the gland secretory fibres from the glosso-pharyngeal. In other words the cerebral autonomic, and the sympathetic autonomic. These two nerve supplies have usually an opposite influence on the secretory activity of the glands, and very frequently also on the vascular changes that accompany secretory activity. That there are really two kinds of secretory fibres, called secretory and trophic, the former having to do with the secretion of water and inorganic salts, and the latter with the secretion of organic matter, *i.e.*, with the extrusion of the zymogen granules.

When secretion occurs, it is caused by influences acting on a nerve centre or centres in the medulla oblongata, the exact location of which for the different glands has been worked out in recent years by Miller. The impulses acting on these centres may be transmitted along different nerves coming from the mucous membrane of the mouth, nares, etc., or by impulses which we may call psychic, transmitted from the higher nerve centres. The reflex secretions caused by impulses travelling by the afferent nerve from the mouth, etc., have been called unconditioned, and those from the higher nerve centres, conditioned.

The investigations that have been made on the conditions of psychic secretion of saliva are still more interesting and important. Their importance depends not so much on the information they give us concerning the secretion of saliva as such, as on the methods they afford us for investigating the various conditions that affect the psychic processes associated with the taking of food. Further investigations show there must be an inhibition of psychic stimulation of the salivary centres by other nerve centres. It is of great interest that this inhibition may itself be inhibited by various forms of stimulation of the nervous system.

It is possible when anything excites the cell to secretory activity, such

as a nerve impulse, it does so by causing a change in the permeability of the lumen border of the cell. This change in permeability may be dependent upon alterations in surface tension brought about by the migration of electrolytes to the border. That such a migration of electrolytes does actually occur has been demonstrated by MacCallum.

Other observers believe that when the gland becomes more active, the molecules present in the cell become broken down into smaller molecules and so raise the osmotic pressure of the cell content, with the result that water is attracted from the blood and is then transferred to the lumen.

Other changes noted during activity entail a considerable expenditure of energy. This is indicated by the fact that considerably larger quantities of oxygen are taken up by the gland when it is in an active state than when at rest. Thus, oxygen consumption of the resting gland may be increased five times during active secretion. On account of this increased oxygen consumption it is not surprising that it should be found that the secretory activity of the cell is greatly impaired by a deficiency in oxygen.

We have seen that suppurative parotitis does not belong exclusively to the realm of surgery from operations performed on other organs of the body; that it occurs with startling frequency in many of the medical diseases.

We are familiar with the fact that pyogenic microorganisms that produce septic parotitis have a natural habitat in the human system; that they are innocuous just as long as the individual resistance of tissue and blood plasma confer an immunity or hold them in check; that they are called into activity by any insult or injury to the tissues; that they are disseminated rapidly through the lymph channels into the blood stream or directly into the circulation producing bacteriæmia, from which no organ, if susceptible, escapes their virulence; that cachexia and malnutrition from whatever source are predisposing factors by lessening resistance.

We are further cognizant of the fact that the salivary glands are dependent upon nerve stimuli for their secretion; that a lowered nerve tone from disease or inhibition of the nerve stimuli from surgical shock may so impair the salivary secretion that partial or complete stasis results. It is at this stage that circulating bacteria, having a predilection for gland tissue, produce their lethal results.

From the foregoing facts and case reports and clinical observations, I am convinced that the former theories of the origin of parotid involvement should be expunged.

CONCLUSION

1. That septic parotitis is of hæmatogenous origin.
2. That cachexia and malnutrition by lowering resistance are predisposing factors.
3. That susceptibility of gland is favored by stasis.
4. That secretion of gland is under the influence of nerve stimuli and

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that the incidence of post-operative parotid involvement is neurologically dependent upon surgical shock or inhibition of the secretory and trophic fibres from higher psychic centres.

5. That the gland must be susceptible to pyogenic microörganisms and when affected bacteriæmia exists in all cases.

6. That early incision and drainage are indicated.

7. That the surgical technic advised by Lilienthal and Blair should be employed.

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DRAINAGE IN APPENDICITIS *

A REVIEW OF CASES OF ACUTE APPENDICITIS REQUIRING DRAINAGE AT THE PRESBYTERIAN
HOSPITAL, NEW YORK, N. Y., 1915-1918

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FROM January 1, 1915, to December 1, 1918, 622 cases of acute appendicitis were admitted to the Presbyterian Hospital, New York City. This number includes cases in which the inflammatory process was fairly limited to the appendix itself, and recorded as acute appendicitis; and cases in which the peritoneal cavity presented evidence of varying degrees of contamination or infection from organisms passing through the appendix wall. The latter have been somewhat arbitrarily, but for the most part satisfactorily classified as follows:

1. Acute appendicitis with acute local peritonitis.
2. Acute appendicitis with peritoneal abscess, subcæcal, mesiocæcal, laterocæcal, etc.
3. Acute appendicitis with extraperitoneal abscess, retrocolic or retro-cæcal.
4. Acute appendicitis with acute diffuse peritonitis.
5. Acute appendicitis with progressive fibrino-purulent peritonitis.

Definition of diagnostic terms:

1. *Acute Appendicitis*.—The pathological changes are limited to the appendix, meso-appendix, and in some cases the cæcal wall in the immediate

* NOTE: As a result of the experimental study of certain chlorine antiseptics in localized peritoneal infections in dogs,¹ the antiseptic post-operative treatment of cases of acute appendicitis requiring drainage was undertaken first in February, 1918, as a routine in the wards of the Surgical Service at the Presbyterian Hospital, New York City. Aside from the eighteen cases which have been treated by the writer, the method has been employed by others in thirteen cases of appendicitis and in a number of intra-abdominal drainage tracts accompanying other conditions.² That a fair criterion might be established by which judgment could be passed upon the results attained by the antiseptic method, an analysis of 263 similar cases occurring during the past four years has been made. This period corresponds with that of the follow-up system of the hospital, and is, therefore, especially satisfactory in determining the incidence of certain sequelæ and late secondary procedures.

¹ A Study of the Intra-abdominal Use of Dakin's Fluid and Dichloramine-T Solutions, with Special Reference to Local Peritoneal Infections. *Jour. Exp. Med.*

² The Clinical Application of the Carrel-Dakin Method to Cases of Acute Appendicitis Requiring Drainage. *Surg., Gynec. and Obst.*

vicinity of the base of the appendix. The serosa of the appendix must show acute inflammatory change, *i.e.*, redness. Fibrin deposit usually is present in some degree. Gangrenous areas of the wall or extensive gangrene of the appendix may exist. A very recent perforation may be present. Free peritoneal exudate, clear, cloudy, odorless or with faint odor may be found.

2. *Acute Appendicitis with Acute Local Peritonitis*.—Lesions of the appendix present are those of acute appendicitis with a larger percentage showing gangrene and perforation of the wall. Acute inflammatory changes are present in the coils of intestine adjacent to the appendix; *i.e.*, redness, changes in lustre, and in many instances fibrinous deposits; omentum shows various stages of involvement. Exudate is present as in the former condition, or there may be a definite odor to the pus without localization. The latter often indicates a transitional stage between acute local peritonitis and peritoneal abscess.

3. *Acute Appendicitis with Peritoneal Abscess*.—The appendix usually presents signs of advanced inflammatory changes. One or more localized collections of definite pus must be present. In most instances this is foul smelling, but may be odorless. The pocket of pus may be walled off by organized adhesions, but often minimal delicate adhesions of fibrin alone are found. Outlying localized or diffuse peritonitis with free exudate may occur, and in such cases the additional diagnosis is given and cross-referenced.

4. *Acute Appendicitis with Extraperitoneal Abscess*.—Includes cases in which the abscess from the appendix originates in tissues without the general peritoneal cavity and involves the extraperitoneal areolar connective tissues.

5. *Acute Appendicitis with Acute Diffuse Peritonitis*.—Any of the above lesions of the appendix may be present. Serosa of the intestinal coils as far as exploration is carried shows uniform inflammatory changes: redness with diminution of lustre or deposits of fibrin or fibrino-purulent exudate. Distention of the intestine is usually found. Exudate is free, clear, cloudy, odorless or odoriferous.

6. *Acute Appendicitis with Progressive Fibrino-purulent Peritonitis*.—This term is restricted to the comparatively rare condition in which the intestinal coils as far as exploration is carried are found with surfaces glued together by organized fibrino-purulent exudate. Bleeding occurs when the attempt is made to separate the coils. Numerous pockets of pus are present between the adherent intestines.

These terms represent stages in the progress of infection of varying degrees of virulence in individuals of varying resistance discovered at operation at varying periods of time from the onset of the attack.

The following table gives the totals of the cases of the various types during the years mentioned. The cases of peritoneal abscess with accom-

panying local peritonitis are included with the first condition; those of peritoneal abscess with acute diffuse peritonitis are given in the column of the latter condition.

TABLE I

Year	Acute appen- dicitis	Acute appen- dicitis with acute local peritonitis	Acute appen- dicitis with abscess (peri- toneal and extraperi- toneal)	Acute appen- dicitis with acute diffuse peritonitis	Acute appen- dicitis with progressive fibrino- purulent peritonitis	Yearly total
1915.....	93	26	57	11	0	187
1916.....	74	30	41	11	0	156
1917.....	62	30	40	7	1	140
1918.....	79	22	34	4	0	139
To December 1						
						622

Five hundred and eighty-nine of these 622 cases were operated upon, and with few exceptions, operation followed immediately upon the establishment of the diagnosis, regardless of the stage of infection. The appendix was removed, if at all accessible, and the wound either entirely closed, or mural or intra-abdominal drainage instituted.

The operator's conception of the infective status of the case determines his procedure in regard to peritoneal drainage, or closure of the abdominal wall. It is probable that in most cases of acute appendicitis a more or less active contamination of the peritoneum is in progress as early as twelve hours.³ The great reserve power of visceral and parietal peritoneum and omentum in combating infection is called into play. Through the agency of their blood-vessels and lymphatics, these structures respond to the bacterial insult, and during the interval preceding operation may afford adequate protection of the peritoneal cavity at large. The fact that many cases survive one or more attacks of acute appendicitis without operative interference testifies to the very considerable power of the peritoneum in dealing with infections. This knowledge gives the surgeon confidence in closing the peritoneum after removal of its infecting focus, in dealing with the lesions of the first type (acute appendicitis) and early or mild cases of the second type (acute appendicitis with acute local peritonitis). In many instances, however, the wall of the appendix early becomes badly compromised and the bacterial invasion thrown upon the peritoneum is so great that its defensive mechanism is strained or overtaxed. An intense, local peritonitis usually appears in response to the injury, and a peritoneal exudate rich in bactericidal elements is thrown out. With a heavy bacterial contamination, phagocytosis can-

³E. Moschcowitz: The Pathological Diagnosis of Diseases of the Appendix Based on the Study of 1500 Specimens, *ANNALS OF SURGERY*, June, 1916.

not keep pace with bacterial growth, and the exudate rapidly becomes foul and purulent. It is this transitional stage between contamination and progressive infection, between a strained and an overtaxed peritoneum that constitutes the border line between those cases that may be closed safely and those in which intraperitoneal drainage seems a necessity. If the peritoneal cavity be closed, one must feel reasonably certain that the residual infection will be taken care of without even the formation of a localized abscess. The infective status of the case must be determined from a consideration of the condition of visceral and parietal peritoneum, the omentum and the character of the exudate present. Briefly, if the peritoneum over a considerable area shows a definite disappearance of gloss or is covered by fibrino-purulent exudate, and the free exudate is odoriferous, indicating a decline in its bactericidal properties, most surgeons decide upon intraperitoneal drainage. The condition of the appendix, if removable, is of secondary importance.

If infection has progressed to the stage of intraperitoneal abscess, drainage becomes almost imperative. There was but one exception to this rule in the cases reviewed. In this instance, empyema of the appendix was present and there was a small amount of odorless, creamy pus about the appendix; the visceral peritoneum did not appear compromised. Following removal of the appendix and evacuation of the abscess, the peritoneum was closed. The procedure was followed by a favorable outcome. Culture of the pus proved sterile. While occasionally it is possible to differentiate a "cold" abscess of this type, and despite the probability that outlying pus pockets in advanced infections are occasionally taken care of by the peritoneum, it would seem more the part of wisdom to make provision in these cases for escape of any necrotic tissue that may line the cavity.

The advisability of drainage in acute appendicitis with diffuse peritonitis is often questioned. The picture indicates that the mass of infection is great or the resistance of the individual below par. Whether drainage from the general peritoneal cavity continues for an hour after operation or for one or two days,⁴ it would seem advisable to afford the peritoneum whatever advantage drainage may give. In some instances adhesions about the drainage tubes probably form as rapidly as fibrin can be deposited between the surrounding coils and escape of infective exudate is slight; on the other hand, it is possible that there may be but little attempt at adhesion formation and the fluid from a considerable part of the cavity may find exit for a more prolonged period. While it is doubtful if conclusions of much value may be drawn from infections in dogs, it was interesting to observe the entire absence of adhesions in one case of diffuse peritonitis autopsied twenty-four hours after drainage.⁵

⁴ Murphy, J. B.: Quoted by F. Matthews, Johnson's "Operative Therapeutics."

Finally, in the cases of acute appendicitis with progressive fibrino-purulent peritonitis, if operation is attempted, the advisability of drainage cannot be questioned.

Closure of the peritoneum and drainage of the tissues of the abdominal wall is a practice which arose as a result of the observation that in certain cases of acute appendicitis with a degree of localized infection that might be safely controlled by the peritoneum, the contamination of the wound during operation led to its secondary infection. In other words, it is a recognition of the lesser ability of the structures of the abdominal wall to deal with the infecting organisms.

The accompanying Table II represents dispositions of the cases of Table I, together with secondary infections occurring in the first two groups, duration of hospital stay, and mortality.

Conclusions as to duration of suppuration, time of hospital stay, secondary procedure, condition of wound on discharge, subsequent ventral hernia, etc., have been prepared from a tabulation of the 263 cases. There are certain reasons why deductions from the total number of drainage cases should prove more fair and valuable than those drawn from arbitrary groups. A very large percentage of the cases in which intra-peritoneal drainage was used were those of advanced infection. Many of the 71 cases classed as acute localized peritonitis had free foul pus and their subsequent course in certain instances seemed to be that of a diffuse peritonitis; 178 had definite abscess formation; 33 cases were classed as acute appendicitis with acute diffuse peritonitis, some of these having one or more subsequent abscesses. The inclusion of a comparatively few minor infections in a group of 263 cases does not affect percentages and places the error to the credit side of the cases treated by simple drainage when we compare results with cases treated by the antiseptic method. A composite view of the disease in its severer form is what one wishes to obtain as a criterion in determining the value of any method of treatment. While the impression made by the pathology of the case rarely deceives the surgeon as to advisability of drainage, a careful reading of the data of operation and post-operative course often leads one to view with suspicion the diagnosis accorded the case. Table II is in consonance with the corrected hospital records. The review of these case histories brought to light numerous errors, in the correction of which the co-operation of several members of the staff was enlisted. Despite the fact that a very considerable amount of time and care was given to this work I do not feel that even now the placing of cases in all instances is free of error or could be rendered so from the recorded data. Reference to the table of case groups is of value in indicating the comparative uniformity of infections received from year to year.

* Rulison: A Study of the Intra-abdominal Use, etc., *ibid.*

DRAINAGE IN APPENDICITIS

TABLE II

Year	Acute appendicitis	No operation	Appendicectomy	Appendicectomy with mural drainage	Appendicectomy with peritoneal drainage	Secondary infection wound	Hospital stay—average	Deaths	Acute appendicitis with acute loc. peritonitis	Appendicectomy	Appendicectomy with mural drainage	Appendicectomy with peritoneal drainage	Secondary infection wound	Hospital stay—peritoneum closed	Hospital stay—peritoneum drained	Deaths	Acute appendicitis with abscess, peritoneal and extraperitoneal	Appendicectomy with mural drainage	Appendicectomy with peritoneal drainage	Incision and drainage	Hospital stay—average	Deaths	Acute appendicitis with acute diffuse peritonitis	Appendicectomy with peritoneal drainage	Hospital stay—average	Deaths	Acute appendicitis with prog. fib. pur. peritonitis	Appendicectomy with drainage	Deaths
1915.....	93	11	69	11	2	5	262 cases; peritoneum closed	1	26	6	2	18	2	32 cases	65 cases (Dakin [6] not incl.)	2	57	0	50	7	148 cases (Dakin cases [23] not incl.)	5	11	11	22 cases (Dakin cases [23] not incl.)	1	0	0	0
1916.....	74	9	56	4	5	5		1	30	5	2	23	3			1	41	1	37	3		4	11	11		0	0	0	0
1917.....	62	6	44	9	3	6		0	30	10	2	18	0			0	40	0	38	2		1	7	7		1	1	1	1
1918..... (11 mos.)	79	6	58	11	4	1		0	22	3	2	17	1			2	34	0	31	3		2	4	3		0	0	0	0
Totals...	308	32	227	35	14	17	12.5 days	2	108	24	8	76	6	14* days	22.2* days	5	172	1	156	15	27.2 days	12	33	32	41.2 days	8	1	1	1
							0.0065%								4.6%						7%				25%				

* Average all cases 19.1 days (Dakin except).

REVIEW OF 263 CASES OF ACUTE APPENDICITIS WITH INTRAPERITONEAL DRAINAGE

Type of Incision.—This is of interest only as indicating accuracy of diagnosis and from the standpoint of hernia. The intermuscular incision of McBurney was used in 176 cases (67 per cent.); the intermuscular incision with extension into the right rectus sheath (Weir) in 43 cases (17 per cent.); the right rectus incision through the muscle in 30 cases (11 per cent.). The incision through anterior rectus sheath with retraction of rectus muscle towards mid-line (Kammerer) was employed in 2 cases and the transverse incision (Rockey) in 3 cases. A median vertical incision indicating either advanced peritoneal infection or doubt as to diagnosis was used in 9 cases (3 per cent.). An additional stab wound in right flank for dependent drainage of the lumbar gutter was made in 10 cases (3.8 per cent.). Ventral hernia was noted in 21 cases in which the intermuscular incision was used, 6 cases in which the Weir incision was used, and 6 in which the right rectus incision was used. Bulging at the site of scar, not classified as hernia, was present in 18 of the intermuscular cases, 7 of the Weir extension cases, 3 of the rectus and one median. In percentages weak wall or hernia occurred in 22.3 per cent. of intermuscular, 29 per cent. of rectus, and 30 per cent. of Weir extension. There were several instances in which weak wall at site of intermuscular scar with definite bulge improved during the interval of follow-up visits and eventually disappeared. This has been attributed to muscular hypertrophy occurring as the patient resumes active exercise. The larger percentage of hernia in rectus incisions was expected, owing to the pull exerted on the wound by the lateral abdominal muscles. Incision into the rectus sheath also appears to add somewhat to the possibility of hernia.

Pathological Findings at Operation.—Reference to Table II indicates in general the broader phases of pathology presented.

Condition of Appendix.—Not located in 13 cases (4.2 per cent.); apparently not more involved than regional peritoneum, but classed as acute appendicitis in 1 case; acutely inflamed, but not gangrenous in 56 cases (21 per cent.); gangrenous in 185 cases (70 per cent.); perforated in 88 cases (34 per cent.); thrombosis of vessels of meso-appendix in 10 cases (3.8 per cent.); abscess of meso-appendix, 3 cases.

Exudate.—Clear, free fluid was noted in 10 cases, cloudy free fluid without odor in 63 cases, free foul exudate in 14 cases, pus not localized in 32 cases. In 137 of the 178 cases with abscess the size of the collection was recorded; of these, 65 were collections of more than two ounces; 72, collections of less than two ounces. Multiple pus pockets were present in 9 cases (3.4 per cent.). Odorless pus was noted in 22 instances, foul pus in 130 instances, or nearly 50 per cent. of the total group.

The various locations of the appendix and pus collections are of interest and importance from several viewpoints. In several of the cases

with acute diffuse peritonitis, rapidly terminating fatally, the appendix has been found lying free on the pelvic brim or in a mesial direction. On the other hand, with very few exceptions, the retro-, latero- and sub-cæcal positions have given rise to a more localized peritonitis and have favored circumscribed abscess formation. Our records of the past four years are in consonance with the opinion, often expressed, that the rapidity of the development of symptoms and the clinical course of the case is dependent largely upon the position of the appendix.

The location of the pus collection is of particular interest in considering drainage procedures and will be referred to under that heading. The following is a summary of the various abscesses recorded in the 263 cases reviewed.

Extraperitoneal abscesses: Laterocolic, 4; retrocæcal, 5; retrocolic, 3.

Peritoneal abscesses: Laterocolic, 18; mesocolic, 15; pelvic, 54; pro-cæcal, 10; retrocæcal, 41; subcæcal, 21; subhepatic, 3; right hypochondriac, 1.

The yearly totals of these various appendix and abscess locations show a very marked close uniformity.

Edema of the properitoneal tissues was noted many times, but definite cellulitis of abdominal wall tissues was recorded in but 7 cases. This is strong evidence of the view that prior to operation the abdominal wall may be said to be free of gross infection.

Bacteriology.—Cultures of exudate or pus were taken in 189 of the cases, at the time of operation. These, for the most part, were aerobic only. Thirty cultures (16.3 per cent.) proved sterile. In nearly every instance these were exudate cultures obtained in the acute appendicitis or acute appendicitis with acute local peritonitis groups. In only two instances were organisms present on smear which failed to grow. The following is a list of organisms recovered either alone or symbiotically.

B. Coli Communis, 114 of 116 positive cultures (71 per cent.) *B. Coli Communis*, 3.

Streptococcus (not further differentiated), 75 times—47 per cent.

Streptococcus hæmolyticus, 5 times. *Streptococcus non-hæmolyticus*, 17 times.

Some form of streptococcus was recovered in 97 cases, or 60 per cent.

Staphylococcus, 18 times—11.3 per cent.

Of the rarer forms recovered: *Bac. Friedlander*, 4; *Pyocyaneus*, 4; *B. Proteus*, 4; *B. Lactis Aërogenes*, 5; *B. Fecalis Alkaligenes*, 3; *B. Mucosus Capsulatus*, 3; *Pneumococcus*, 2; *Micrococcus Tetrages*, 1; *B. Paratyphosus*, 2; *B. Diphtheriæ*, 1; Gram-negative bacilli not further differentiated were reported in 10 cases; Gram-positive bacilli in 6 cases; Gram-positive coccus in 5 cases.

The association of some form of streptococcus with the colon bacillus was by far the most common (44 cases).

The association of streptococcus with *B. Pyocyaneus*, *B. Friedlander*, *B. Fecalis Alkaligenes* was observed in several instances.

Pure cultures of *B. Coli Communis* were reported in 42 cases; pure cultures of some form of streptococcus in 13 cases. Pure cultures of staphylococcus aureus and albus and *B. Coli Communis* were also reported.

The type of organisms recovered at operation does not seem to furnish any information of prognostic value. The various symbioses noted above were found alike in mild and severe grades of peritoneal infections. Cultures were taken in 6 of the 8 fatal cases with acute diffuse peritonitis with the following results:

History No. 32100; death two hours after operation. Streptococcus.

History No. 35951; death twelve hours after operation. Gram-negative diplococcus; Gram-negative bacillus; staphylococcus.

History No. 31879; death sixteen hours after operation. Bac. *Coli Communis*; streptococcus.

History No. 35468; death four days after operation. Bac. *Paratyphosus*.

History No. 21685; death seven days after operation. Bac. *Pyocyaneus*; Bac. *Coli Communis*, *B. Proteus*.

History No. 31294; death seventy-four days after operation. Streptococcus non-hæmolyticus.

Cultures were made in 16 of the 22 recovered cases of the same group. Six pure cultures of *B. Coli Communis* and five cultures of Bac. *Coli Communis* with some form of streptococcus were reported. In the remaining 5 cases there was a pure culture of streptococcus; Bac. *Coli Communis* with *B. Fecalis Alkaligenes*; Bac. *Coli Communis* with a staphylococcus (2 cases); *B. Coli Communis* with a Gram-positive diplococcus.

Methods of Drainage and Post-operative Care of Wounds.—There is probably no common surgical condition that is more variously treated than the one under consideration. The cases reviewed were those of fifteen operators, and the manner in which the cases were handled was varied, both from the standpoint of the different operators, and also in regard to similar cases of the same operator. The inference that may be drawn is that, as in any condition in which the therapeutic measures employed are legion, no one is entirely satisfactory. Each operator's procedure is necessarily based upon his surgical training and experience. The tendency to standardization of treatment was especially noticeable in reading the cases of the operators of longer surgical experience. The cases were tabulated in such a manner that the results of operators using different methods might be determined. For example, Surgeon A. invariably placed a cigarette drain to pelvis and a gauze drain to stump of appendix which was tied off. His post-operative wound cure was an early removal of the gauze drain and a late removal of the cigarette drain with only occasional irrigation of drainage tract. Surgeon B. invariably placed a single large calibre, thin-walled, soft rubber drainage tube to pelvis and on the second or third day substituted a soft rubber catheter through which the tract was irrigated daily by salt solution or boric solution. Each operator had about the same number (28 and 30) of cases,

extending over the past four years, and their cases compared closely in type. A comparison of their results will be taken up later.

In reviewing the cases of the men of shorter experience, changes in procedure from case to case was particularly noticeable. Surgeon C., for example, was having very good results with rubber tube drainage, loosening the drain on the first or second day, removing it about the fifth to irrigate the tract, and then replacing it daily until discharge was diminished and tract clean. One of his cases develops a fecal fistula with the drain still *in situ* on the tenth or twelfth day. A discussion occurs at the bed-side and the rubber tube is blamed, perhaps justifiably. In his next few cases he either removes the rubber tube earlier or substitutes at operation a cigarette drain for the tube. If he decides to remove the drain earlier or shorten it a half inch daily, all goes well until some case develops a residual abscess at the depth of the tract; if he has transferred his allegiance to cigarette drains he may soon become dissatisfied on observing the inefficient drainage; an outpouring of an ounce or two of dammed-back pus on removal of the drain.

The results of the operators of long experience using standardized technic and not disturbed by the occasional wound complication, were, in general, better than those of men either attempting to individualize in their cases, or occasionally employing methods aimed at circumventing certain complications. Strangely enough, under the simple (as opposed to antiseptic) method of treatment the results attained under standardized but diametrically opposed methods were about the same.

There are certain underlying principles which all surgeons have in mind in the treatment of appendiceal infections. If at operation a well walled-off collection of pus is found and entered without contaminating the general abdominal cavity, the appendix is removed, if this can be done without breaking up protective adhesions, and the infected locality is drained. If free pus is present it is usually found in the pelvis and right lumbar gutter and drains are placed to these regions. As a rule, the drains are allowed to extend through the operative wound. Many have advocated and several practiced the separate drainage of the right lumbar gutter through a stab wound in the loin. The rationale of this procedure is unquestionably good from an anatomical viewpoint, as true dependent drainage is only in this way obtained. There have been no cases of vaginal or rectal drainage in this series. The drainage from the pelvis through tubes protruding from the abdominal wound is vertically upward with patient in Fowler or Gatch position. On the other hand, tubes to the right lumbar gutter in these positions have a horizontal direction or a few degrees of downward inclination. There were ten cases in which loin drainage was employed. All had retrocæcal, retrocolic or laterocolic abscess, three having retroperitoneal abscesses. Three cases resulted fatally, one from tuberculous broncho-pneumonia, the other two as a result of their infection which in each instance was of a severe

grade. In the 59 cases of latero- or retrocæcal and retrocolic abscesses drained through the anterior wound, drain was placed to the right lumbar gutter in 13 instances, and there was 1 death. This, at least, does not support the claims of decreased mortality made by some in favor of stab-wound drainage. On the other hand, it does not constitute a valid objection to its employment. Perhaps a greater argument than dependent drainage that might be urged in favor of loin drainage is that it permits the establishment of a straight tract. A drain placed to the lumbar gutter and emerging from an intermuscular or rectus incision must necessarily describe a curve, and the tube is therefore prone to buckle and prove inefficient. Tortuous tracts are often handled with success by late removal of the drain or the substitution of a small catheter after a few days, but they usually prove a worry.

Fenestrated, thin-walled, soft rubber tubes are to-day generally recognized as combining the highest grade of efficiency in drainage with the least danger of harm to the infected intestinal wall. The cigarette drain (gauze wapped with rubber tissue, rubber dam or gutta percha), while causing less pressure on contacting intestine, is quite worthless as a drain after a few hours. That cases do well with cigarette drains *in situ* is due to escape of exudate about the drain after it has been loosened, or, if multiple drains have been introduced, after the removal of one of them. In comparing the results of surgeons A. and B., the former, using cigarette drains, had 3 cases of fecal fistula in 30 cases; surgeon B. substituting a catheter for rubber tube drain on the second or third day had no fecal fistulæ develop in his 28 cases.

The type of drain most frequently employed was the double-arm tube, devised by Dr. Joseph A. Blake. The tube is so fashioned that the deep ends of the two arms are held together by a narrow connecting portion of the tube wall. One arm is fenestrated and provided with a gauze wick which affords capillarity between the depth of the tract and the wound dressing. The wick also tends to prevent possible insinuation of a process of omentum into the lumen of the tube. The other arm is non-fenestrated and left open; it provides another avenue of escape of exudate, and permits the introduction of a catheter for irrigation at the daily dressing. Tubes of this type were used in 114 of the 263 cases (44 per cent.). Single fenestrated tubes with gauze wick were employed either alone, with the double arm tube, or multiple single tubes in 97 cases (37 per cent.). Cigarette drains, single or multiple, alone or with rubber tubes in 73 cases (28 per cent.). Gauze drains were employed in 22 cases and only as an adjunct to other drains, and were invariably removed early. Other drains occasionally employed were rubber dam in 4 cases, small rubber tubes inclosed in silk in 2 cases, Mikulicz drain in 1 case, and rubber tissue in 1 case.

Drain was placed to pelvis either alone or with drain to other regions in 144 cases (54.7 per cent.); to cæcal region in 119 cases (45.2 per cent.);

to right lumbar gutter in 23 cases (9 per cent.). In 10 cases a lumbar gutter drain was introduced through a stab wound in the loin. In 37 cases drains were placed both to pelvis and cæcal region. In a few instances other regions were drained, as the pathology required, *e.g.*, subhepatic abscesses. One subhepatic abscess was drained with success through the intermuscular incision, although the tract was necessarily a very long and a sharply angulated one. In one case the drain was placed just within the peritoneum, the abscess being procæcal. Drains in the superficial wound were introduced as adjuncts in 9 cases.

The post-operative care of the wound was various but found to resolve itself into (1) a loosening and gradual and progressive shortening of the original drains; (2) early or (3) late removal and replacement by the same size or smaller size drains or catheter, the wound usually being irrigated by saline or boric solution at the daily dressing. The first method of gradual shortening was employed in 62 cases (24 per cent.); in some of these cases a small drain was introduced after the late removal of the original drain. In 102 cases, 38.8 per cent., the original drains were removed and replaced either by the same or smaller tube during the first four days; in 111 cases (42.2 per cent.) replacement was effected subsequent to the fourth day. Daily irrigations were the rule in the tube-drain cases. With the double-arm tube this was accomplished early, before removal of drain, by loosening and slightly withdrawing drain and the introduction of the irrigating catheter to the depth of the closed arm. After a period of four to five days, the double tube was frequently removed, a catheter inserted to the depth of the tract and irrigation was followed by replacement of one arm of the tube. Another method has been alluded to, of replacing the drainage tube by a soft rubber catheter early or late, and allowing this to remain in the wound as a drain, and to facilitate daily irrigation.

The progress of wound infection and repair under these varying methods of treatment was strikingly similar; the results attained by men skilled in the employment of diametrically opposed procedures were almost identical. Taking the cigarette drained cases with late replacement, or gradual shortening with occasional or no irrigation in comparison with the tube-drained cases with early replacement and daily irrigation through catheter, the former reached a stage of clinical cleanliness when drainage could be safely discontinued in the average case on the fourteenth day; the latter on the sixteenth day. Evidence of inefficient drainage was noted in two cases of the former and only one of the latter. The character of discharge and infection of abdominal wall was similar—slough of aponeurosis was noted in 8 and 7 cases, respectively. Under the former treatment three fecal fistulæ appeared; one of these occurring in a tuberculous subject in which a tuberculous peritonitis was found at a later operation; no fecal fistula occurred in the latter. There was one case of secondary abscess under each type of treatment. Thrombophlebitis of internal saphenous vein occurred once in each group. The

wounds on discharge showed an interesting variation in the former, but three cases having a discharging sinus, in the latter seven cases. In general, however, the wounds showed similar stages of healing. The average hospital stay was twenty-three days in each. One death occurred in each. The follow-up cases yielded similar results in herniæ and weak abdominal walls.

In a perusal of the dressing notes of many of the cases, one cannot but be impressed by the number of manœuvres which were decidedly painful to the patient, and the net gain of which proved to be extremely small, if any. The practice, which has been rather common, of removing a large drainage tube from a deep tract which in many cases proved to be more or less tortuous, irrigating the tract and then attempting to reinsert the same tube, should certainly be condemned. The objections, if any, of replacement by a small drain are more than offset by the possible injury that may be done to the delicate wall of the drainage tract and the suffering caused by instrumental introduction of a large tube. With the technic of antiseptic treatment described in another paper,⁶ the patient can be said to enjoy complete freedom from painful dressings.

Viewed in the light of the post-operative course of the cases treated throughout by the introduction of adequate quantities of Dakin's fluid, the greater number of these 263 cases treated by simple drainage present an unattractive picture. It is quite analogous to the startling change said to have been made in the course of war wounds when treated either by débridement or by the Carrel-Dakin method.

An effort has been made to summarize the course of the cases as a whole, in regard to efficiency of drainage, wound complications, degree of suppuration, and destruction of abdominal wall tissues, including wound disruptions. There were 36 cases (14 per cent.) in which wound drainage was inefficient, evidenced by the sudden outflow of a considerable quantity of exudate on loosening or removing the drain. The causes were various: cigarette drains acting as plugs, buckling of the rubber tubes and clots of fibrin within the lumen of the tubes were found the more common. Hemorrhage from the wound occurred in 7 cases (2.7 per cent.); in one case a fatal issue was barely averted by transfusion and secondary operation for control. Hemorrhagic oozing was present in two other cases. It was possible to ascertain the degree of suppuration in 207 cases. Slight suppuration throughout was recorded in 19 cases (9 per cent.); moderate in 55 (26.5 per cent.), and profuse in 133 (64.5 per cent.). Odorless discharge was noted in but six of 179 cases (3.3 per cent.); foul discharge at some period of the post-operative course in 173 cases (96.7 per cent.). The presence or absence of slough was recorded in 143 cases. In 11 cases only did the histories indicate an absence of slough. In 31 cases

⁶Rulison, E. T., Jr., M.D.: The Clinical Application of the Carrel-Dakin Method to Cases of Acute Appendicitis Requiring Drainage.

the slough was evidently superficial or from the abscess wall; in 100 cases there was a definite necrosis of the aponeurosis of the external oblique (70 per cent.). While at first glance this percentage may seem high, it was arrived at by as fair an interpretation of the records as was possible. A large number of cases in which dressing notes were meagre undoubtedly had slough of aponeurosis, but, of course, have been excluded. I believe that the number of cases of this kind excluded more than offsets the number in which no slough had occurred. That the sloughing out of the aponeurosis has been considered rather in the normal course of events in these drainage cases receives confirmatory evidence from the history notes. For example, in History No. 22071, on the sixth day "considerable slough removed from wound," and on the eighth day "sloughs are beginning to separate," and on the twelfth day "tubes placed to depth of pelvis relieving pocket at deep portion," and on the twenty-fifth day "patient leaves hospital with a discharging sinus, having made *an uneventful recovery*." In History No. 30374, on the eighth day a note was made of "considerable slough," and on the tenth day "large piece of sloughs removed;" on the forty-second day "wound healed with crust. sinus, having made *a good recovery*." In History No. 37256, on the tenth day "one slough of external oblique removed;" on the eleventh day "large sloughs removed;" on the twenty-fourth day "wound healed with crust. He had a *characteristic sloughing* of the wound with loss of much external oblique aponeurosis, leaving him with probable chances of ventral hernia."

A recent house surgeon asserted that during his service he had never seen an appendix abscess which had not sloughed out a portion of the aponeurosis. To quote from the records of some of the cases not making as good recovery as those cited above, in History No. 20366, on the fourth day "wound lined by slough, caput coli presenting;" on the ninth day, "cæcum bulged into wound and was packed back." In History No. 20602, on the sixth day "several sloughs removed;" on the eighth day "internal oblique separated 1 inch, intestine in wound." In History No. 33978 on the seventh day "much slough;" on the ninth day "great many stinking sloughs removed;" on the eleventh day "condition of wound fair, no sloughs." In History No. 36281, on ninth day, "large piece of slough;" on tenth day "several pieces of slough;" on the fourteenth day, "large piece of slough *with chronic sutures*;" on sixteenth day, "large pieces of slough." In History No. 37242 on the eleventh day "cellulitis with disruption of wound;" on the 13th day "enormous amount of slough, mostly aponeurosis, removed;" on the twenty-first day "one piece of slough." In History No. 33638, on the eighth day, "fecal fistula has appeared;" on the tenth day "gut in wound;" on the fourteenth day "wound a granulating cavity formed by coils of intestine and abdominal wall. Skin edges show effect of sloughing, having an irregular worm-eaten edge. Discharge a bright yellow liquid with curds." In History No. 20734, on the fifth day, "wound wide open. lined by sloughs; aponeurosis sloughing away;" on the seventh day "con-

siderable slough;" on the ninth day "abscess beneath the abdominal wall opened by finger drain;" on the tenth day "sheath of rectus entirely sloughed out." These quotations were taken almost at random from the 100 cases in which slough of aponeurosis was recorded. The character of discharge present, the foul, stinking "colon" odor that greets the surgeon when the bedclothes are turned down at the daily dressing, the odor that the patient has to endure for a period of a week or ten days and often longer, is familiar to all. The dressing notes abound in vivid characterizations of the odors emitted by the wounds.

Actual hernia of intestine into wounds was referred to in 9 cases, and a more moderate degree of wound disruption in 12. Mural abscesses occurred in 17 cases.

The average period of suppuration was estimated in 204 cases as 15.4 days. At the end of this period the wound might be said to be "clinically clean" and necessity of drainage no longer present.

Complications.—*Fecal fistula* appeared in 18 cases, or 7.5 per cent. of the cases which recovered. There were two fistulae among the 24 fatal cases. Twelve fistulae closed spontaneously; two were closed by operative procedure and five failed to close. Three cases were discharged from the hospital with fecal fistula, one of these after an unsuccessful operative attempt at closure.

Analysis of these 18 cases of fistula yields the following data: In 10 cases rubber-tube drainage was employed, in 5 cases cigarette drains, and in 3 cases both rubber tubes and cigarette drains. In 15 cases the post-operative wound management consisted of a gradual shortening or a late replacement of drains by smaller drains or reinsertion of the original drain. In only two cases in which the original drain was early replaced by a small drain, that is, before the fourth day, did fistula develop. One of these two cases, History No. 35099, was treated by removal of the cigarette drain on the second day and attempt at replacement by a catheter failed. The case began to show a mounting temperature and on the fourth day a catheter was passed instrumentally in a direction the original drain had taken for a distance of six inches. On the tenth day a rubber tube was substituted and on the following day a fistula appeared. Evidence of injury to the drainage tract by forcibly introducing drains was found in 4 cases. There was one case of fistula resulting from deliberate opening of a knuckle of intestine in wound to relieve ileus.

Consideration of these findings lends evidence to the views generally held regarding the development of this complication. The prolonged tube pressure against an infected intestinal wall undoubtedly causes an area of localized necrosis. The very low incidence of fistula in cases treated by an early substitution of a smaller drain or catheter is strong confirmatory proof of this view. The importance of handling abdominal drainage tracts with gentleness is emphasized by the appearance of fecal fistula in 4 of 16 cases in which secondary wound procedures were necessary

to improve drainage. In the antiseptic treatment of drainage tracts described in another paper⁷ these considerations are given due weight. Efficient contact of antiseptic with tract wall necessitates the early exchange of tube for catheter which is introduced with minimal injury to the tract wall. The tendency to restraint of infection afforded by the antiseptic may also prove a factor in lessening wall destruction.

Of the strictly abdominal complications, *secondary abscesses* furnished the greatest number. The 17 cases of mural abscess have been mentioned. There were 21 cases of secondary peritoneal abscess (8 per cent.), 12 in pelvic position, 3 subphrenic, 2 subhepatic, 2 right lumbar, 1 in subsplenic, and 1 in left lower abdomen. Spontaneous evacuation resulted in 3 cases through wound and in 1 case by rectum. Eleven secondary collections were drained by approach through wound, usually the insertion of a finger with patient under nitrous-oxide-oxygen anæsthesia. Six were drained through separate abdominal incisions. Abdominal masses thought to be secondary abscesses disappeared spontaneously in 3 cases.

Paralytic and mechanical ileus were comparatively rare complications, the former occurring in 7 cases (2.6 per cent.) and the latter in but 3 cases (1.1 per cent.). This excellent record is due, it would seem, to the close observation that the cases receive and deserve, and the prompt institution of treatment directed towards relief of complications. In general the management of a case with peritonitis of any degree has been to allow little or no fluids by mouth, colonic irrigations at intervals of six or eight hours, beginning about 12 hours after operation, gastric lavage repeated at intervals of six or eight hours if vomiting or distention indicate. Deficiency of fluids has been met by proctoclysis, hypodermoclysis, intravenous infusion of normal saline or glucose solutions. The withholding of fluids or food by mouth until gastro-intestinal peristaltic movements have become orderly usually affords the patient a course uncomplicated by paralytic ileus. Care in the placing of drains is, of course, an important prophylactic measure for ileus of mechanical type. The proper beveling of drainage tube ends and the compressibility of the tube walls are details of no little importance. When we reflect that it is asserted that it requires but a weight of 5 to 8 grammes to check the onward movement of contents in the dog's normal intestine,⁸ it is surprising that in these infected cases we meet the condition of mechanical ileus so infrequently.

Of the 10 cases of ileus, there were 3 deaths due to failure to relieve the condition. Of the 7 recovered cases, 4 recovered without surgical intervention and 3 after operative procedure for relief. Of the 4 recovering without operation, 3 were of paralytic variety, the other what was thought to be an early mechanical ileus. Two of the three cases recovering after operation were of the mechanical type. None of the mechanical ileus cases died of

⁷ Rulison, E. T., Jr., M.D.: The Clinical Application of the Carrel-Dakin Method to Cases of Acute Appendicitis Requiring Drainage.

⁸ Cash: Johns Hopkins Hospital Reports, i, 93, 1896.

the condition. Operation revealed adhesions with kinking of the intestine in one case, and obstruction from tube pressure in the other. Paralytic ileus in the three fatal cases was a terminal condition, a symptom of the unchecked progressive infection. In only one of these cases was operative relief attempted.

There were 3 cases of acute dilatation of the stomach, all being relieved by lavage and change of position.

Of the complications not immediately abdominal, those of the respiratory tract were most numerous. Acute bronchitis occurred in 2 cases, post-operative pneumonitis of lobar type in 17 cases (6.4 per cent.); broncho-pneumonia in 2 cases; empyema in 4 cases; pulmonary infarction in 3; pulmonary embolism in 2; pulmonary tuberculosis in 5 cases, making a total of 36 pulmonary complications, or 13.7 per cent. This high percentage, I believe, has not been generally recognized.

Urinary complications were infrequent; acute cystitis in 2 cases and acute uræmia in 2 cases.

Blood-vessel complications comprised 2 cases of thrombophlebitis of the internal saphenous vein and 1 case of embolism of the femoral artery with gangrene of the extremity; pyelephlebitis occurred in one case.

Jaundice was present in 4 cases; acute exanthemata in 2 cases; a toxic erythema in one case that also suffered from an infectious psychosis. Acute rheumatic fever complicated 1 case; otitis media, 2 cases; enterocolitis, 2 cases. There were in all a total of 62 complications (23.6 per cent.) not immediately abdominal in character.

History No. 22301 serves as an illustration of the manner in which some cases may be beset by complications. At operation a gangrenous appendix with a large amount of free pus in the pelvis and right lumbar gutter was found. Visceral and parietal peritoneum showed pathological changes as far as exploration was carried. Operative diagnosis was acute appendicitis with acute diffuse peritonitis. Appendix was removed and a double rubber tube drain was placed to pelvis and a single tube to the right lumbar gutter. Culture showed *Bac. Coli Communis* and *B. Fecalis Alkaligenes*. The wound treatment consisted of loosening and shortening the drains a little on the second day and applying a camphor-wet dressing. On the fourth day the tubes were further shortened and the wound irrigated. Discharge from wound was foul dirty brown to light yellow during the first week and profuse green to thick mucoid during the second week. By the eighth day the wound was gaping and lined by slough. On the twelfth day the cæcum lay exposed in the wound with muscles widely separated; on this day an abscess pocket in the pelvis was opened through the wound. On the fifteenth day a subcutaneous abscess was opened through the wound. On the eighteenth day a secondary abscess to the inner side of the wound between peritoneum and muscles was opened through the wound. On the forty-first day a left thoracotomy was performed for em-

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pyema (culture streptococcus). On the forty-eighth day, fecal fistula appeared; on this same day a residual abscess subsplenic was opened through a left-sided incision. On the fifty-seventh day a small intestinal fistula appeared in the left side of the wound. This fistula closed spontaneously; the cæcal fistula was closed successfully by operation at the fifth month. The patient left the hospital after a stay of 205 days. Three years after the operation he was found to be in good general health. Ventral hernia was present.

Secondary procedures instituted for relief of immediate or remote complications totalled 43 (16.4 per cent.). The following is a list of these operations:

Secondary abscesses (mural or peritoneal)	23
Opened through wound	16
Opened through separate incision	7
Ileus	4
Mechanical	2
Paralytic	2
Fecal fistula	3
Exploratory for residual abscess not found	3
For control of hemorrhage	1
For recovery of fecolith	1
Secondary suture of rectus muscle	1
Skin-graft of wound	1
Amputation of leg (embolism of femoral artery)	1
Thoracotomy	5
<hr/>	<hr/>
Total	43

Late secondary operations will be referred to under follow-up results.

Conditions of Wounds on Discharge from Hospital.—Seventeen cases left with wounds completely healed (7.3 per cent.); 9 cases left with wound area covered by an apparently healthy crust (3.8 per cent.); 87 cases were discharged with small granulating areas at the site of drainage tract (37 per cent.); in 7 cases the granulating area was a large one (3 per cent.); in 43 cases a sinus was present, but discharge negligible (18.5 per cent.); in 66 cases a discharging sinus was noted (29.1 per cent.); 3 cases left with a fecal fistula in one of which operative closure had been unsuccessful. In 8 cases the condition of wound on discharge was not recorded.

The general condition of patients on discharge was good. In a few instances (four) the records state that "patient has lost considerable weight during stay in hospital." The weight of patients on admission and discharge has not been recorded in any of the cases.

The average duration of the hospital stay of the 240 recovered cases was twenty-six and five-tenths days. Late secondary procedures, *e.g.*, repair of ventral hernia, appendicectomy, etc., added one and five-tenths days to the average, making twenty-eight days. The shortest stay was eleven days; the longest two hundred and five days.

Deaths.—There were 24 deaths in the 263 cases; one occurring after a

late secondary operation (subsequent hospital admission), making 9.1 per cent. mortality. The mortality of the different groups is given in Table II.

Fifteen deaths were directly attributable to the peritoneal infection. Pulmonary embolism was given as the primary cause of death in 3 cases. In one of these at autopsy a thrombosis of right and left internal iliacs and infarcts of lung were found. Embolism of the femoral artery with gangrene of the leg and deep sacral decubitus caused death in one case. Pylephlebitis, tuberculous broncho-pneumonia, inanition as a result of a high intestinal fistula, and long continued sepsis resulting from multiple foci (subdiaphragmatic abscess, empyema with fecal fistula) were responsible for four of the deaths. One case was readmitted to the hospital after seven months with acute ileus from band, causing gangrene of a loop of ileum. Death followed resection.

Autopsies were performed in only 3 cases. One has been mentioned. The other two were cases of acute diffuse peritonitis at operation, and death in each case occurred on the seventh day. In one case there were well formed adhesions about the drainage tube but diffuse peritonitis. In the other a progressive fibrino-purulent peritonitis had ensued, numerous pus pockets and areas of necrosis were present in the intestinal walls.

Records of Follow-up Clinic.—One hundred and sixty-five of the 240 cases were followed up over a period of two months to two years (69 per cent.). The cases in which follow-up results are wanting were for the most part private patients.

The time of ultimate closure of the wound was mentioned in 36 cases and the average time after leaving the hospital estimated at five weeks.

Reappearance of discharge from wound occurred in 11 cases (4.6 per cent.). In 4 of these cases chromic sutures were expelled after prolonged periods of discharge.

Time of resumption of work in 17 cases averaged eight weeks. In 2 cases there was prolonged disability; in 1 incapacity for work existed for fifteen months.

The symptomatic results were for the most part excellent. In only 5 cases were there symptoms indicative of residual intra-abdominal pathological conditions.

The records are particularly complete in regard to the condition of the abdominal wall. The weak walls at the site of scars have been noted and described as "bulges," and the term ventral hernia reserved for cases in which a distinct neck could be palpated and definite impulse at the neck felt when patient coughed. "Bulges" or weak walls were noted in 29 cases (18 per cent.) and hernia in 33 cases (20 per cent.). The anatomical results were therefore poor in 38 per cent. of the cases.

Operations for repair of ventral hernia were done in 8 cases with 6 successful results. Hernia operations have been delayed until eight months to a year for two excellent reasons. First, there have been several cases of weak walls with decided bulges which have disappeared spontaneously

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as the abdominal musculature gradually improved in tone. In one or two instances an examiner has actually recorded a hernia which at a later examination failed of verification. A second reason for delay is that pyogenic organisms probably remain enmeshed in the scar tissue of these wounds for a considerable period and militate against success in the hernial repair.

Late Secondary Operations.—In addition to the 8 operations for repair of ventral hernia, there were 3 subsequent operations for removal of appendix in cases that had previously been treated by simple incision and drainage. There was one late operation for closure of fecal fistula. Two cases re-entered the hospital with acute ileus. One has been described under deaths; the other re-entered the hospital seven days after discharge and a peritoneal band from scar to brim of pelvis was divided, the patient making a good recovery. Late residual abscesses occurred in two of the cases, one an omental abscess, admitted eleven months after discharge with history of repeated attacks of abdominal pain and symptoms of partial ileus. Omental abscess was excised and the patient left the hospital after a stay of forty-eight days. A large ventral hernia developed at the site of second operative scar. The other patient entered the hospital five months after discharge and a retrocæcal abscess containing about 100 c.c. of foul pus was opened.

There was a total of 16 late secondary operations (6.6 per cent.) with one death.

We have found in the cases reviewed that the average period of supuration was fifteen and four-tenth days, during which time the wounds discharged foul pus and sloughs. The average duration of hospital stay was twenty-eight days. Among the frequent complications fecal fistula developed in 7.5 per cent. of the cases. Anatomical results were poor in 38 per cent. of the cases. There was a 9.1 per cent. mortality. Whether the course of these cases may be improved in any of these essential particulars by the use of antiseptics is dependent upon their safe application and a determination of their efficiency in this type of infection. A consideration of the post-operative antiseptic treatment of cases of acute appendicitis requiring drainage appears in another paper.⁹

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⁹ Rulison, E. T., Jr., M.D.: The Clinical Application of the Carrel-Dakin Method to Cases of Acute Appendicitis Requiring Drainage.

ANKYLOSING OPERATIONS ON THE TUBERCULOUS SPINE*

LABORATORY EXAMINATION OF A SPECIMEN

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IN the eight years that have elapsed since Hibbs and Albee published descriptions of their operations for ankylosing the spine, various authors have reported many cases, but only a few, laboratory examinations of specimens.¹

My patient was a boy of four years with typical history, symptomatology, and Röntgen picture of tuberculosis of the tenth thoracic vertebra, upon whom I did a Hibbs operation on August 26, 1918. After the operation the child was put upon a Whitman-Bradford frame, and remained on it until October 25, when he was put in a plaster jacket. During this time he suffered at intervals from pain in the abdomen.

The pain grew worse after the application of the jacket, and the child could hardly walk.

On December 24 the jacket was removed, and a small fluctuating swelling was discovered on the third and fourth ribs at their junction with the sternum. The boy was put back upon his frame, and was started on the sunlight treatment. Another skiagram was made of his spine. This showed "disease in the lower thoracic vertebræ, involving especially the tenth and eleventh. Probable union of the eighth and ninth, tenth and eleventh and twelfth. No definite union between the ninth and tenth."

The cold abscess on the front of the chest slowly increased in size, and was repeatedly aspirated. The guinea-pig test proved its contents to be tuberculous, but its origin was never determined. It ruptured and became infected in the following March.

January 31, 1919: Second operation. Dissection of scar. Long incision carried down to vertebræ at site of previous operation. The lateral masses were then laid bare. Bony union had been attained for the most part, but was not complete in one or two places. The laminæ were carefully bared, and, where non-union was suspected, a chip was turned down from their lower border, as in the Hibbs operation.

A piece of the cortex was removed with a circular saw from the antero-medial aspect of the tibia, and was sutured tightly to the laminæ with kangaroo tendon slightly to the right of the middle line. Dry dressing. Patient put back on his frame.

* From the Stanford University Laboratory of Surgical Pathology.

¹ Ely: "Ankylosing Operations on the Spine." A Study of Two Specimens in the Laboratory. *Journal of the American Medical Association*, 1917, lxviii, 183. Gallie: *American Journal of Orthopædic Surgery*, 1916, xiv, 137.

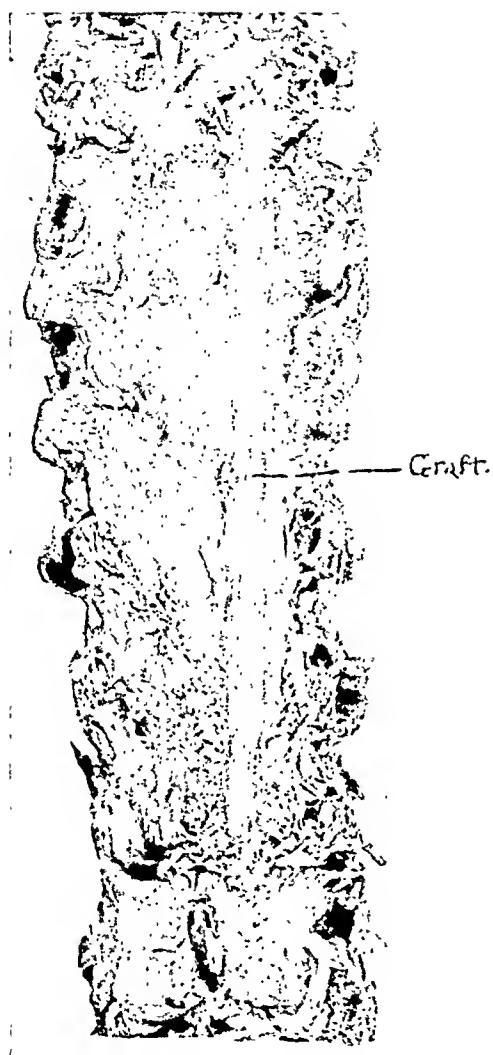


FIG. 1.—Posterior aspect of specimen.

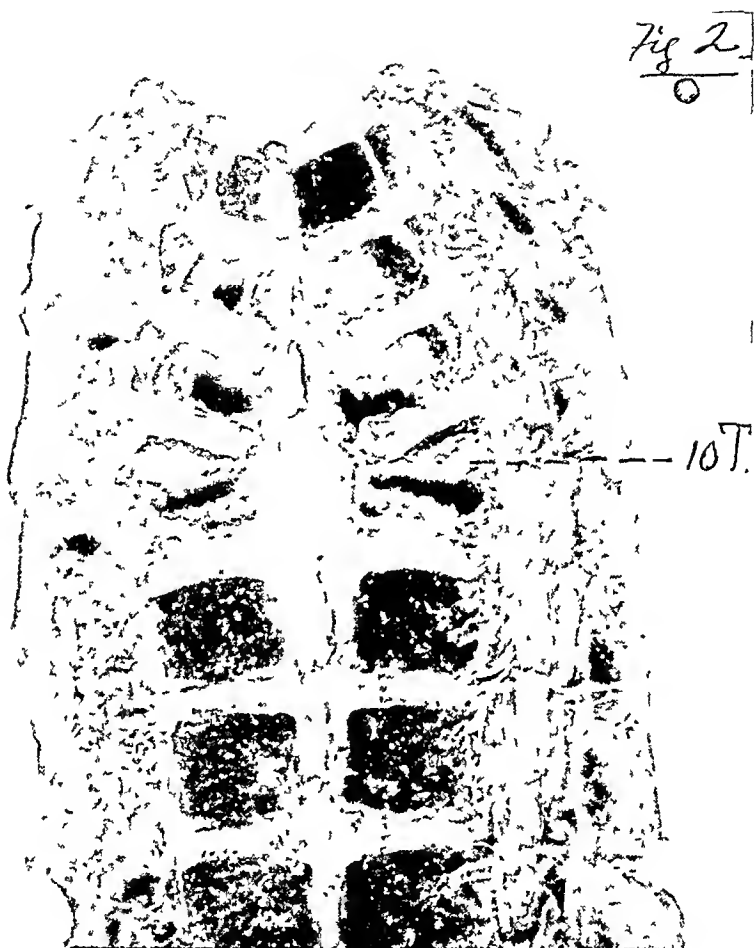


FIG 2 — Specimen laid open from behind

All went well for the next two months, except as to the rupture of the abscess.

In early April the child began to have vomiting spells. Slowly typical symptoms of meningitis developed. Smears from clear fluid withdrawn by spinal puncture showed 95 per cent. lymphocytes and 5 per cent. polymorphonuclear cells, but no bacteria or acid fast bacilli.

Death April 22, 1919. No general autopsy was permitted. The affected portion of the spine, however, was obtained.

Examination of the specimen posteriorly showed a tightly adherent periosteum. When this was dissected off, a solid bridge of bone uniting the eighth, ninth, tenth, eleventh, twelfth thoracic and first lumbar vertebræ was discovered. This bridge of bone is seen to be the result of the union of the laminae, produced by the Hibbs operation, reinforced by the graft, which is apparently firmly united to the lateral masses. The bony structure of the graft is continuous with that of the receiving bones (Fig. 1).

Anteriorly, the bodies of the eighth, ninth, and tenth thoracic are badly diseased. A large part of them evidently has been destroyed, especially on the left side. Fluctuation can be detected under the periosteum on the anterior surface in all three.

The specimen was sawn sagittally, and split open from behind (Fig. 2). Marked involvement of the eighth, ninth, and tenth vertebræ was disclosed. Each of them contained a large cavity filled with necrotic material, fluid and semisolid. Indeed, little bone remains in their left halves, and not much more in their right.

The tenth thoracic vertebra is of the usual wedge shape seen in spinal tuberculosis, as the X-ray showed it to be before the first operation, but the eighth and ninth, though almost as badly involved, have been kept from collapsing by the bony bridge of the laminae. In spite of this bony bridge the disease has steadily progressed.

Histologically the specimen showed typical tuberculosis of the marrow, but no tubercle bacilli were found. The disease was of the rapid destructive type with practically no tendency to encapsulation by fibrous tissue.

After eight years it is possible to draw certain conclusions in regard to these ankylosing operations for spinal tuberculosis.

1. They are curative in a large proportion of cases of what was previously an almost incurable disease.

2. They are not invariably curative. Unlike ankylosing operations on other joints of the body, they ankylose neighboring joints, not the diseased ones, and hence simply provide a splint for the affected region. They provide rest, nothing more. They put Nature in the best possible position for accomplishing a cure herself, but they cause no change in the affected tissues. The lymphoid marrow and the synovial membrane still exist, and afford the proper food for the tubercle bacillus. Consequently we occasionally observe a steady progress of the disease, and

must do another operation above or below the first one, when the tubercle bacilli invade the bone marrow above or below the ankylosed area.

3. These operations shorten greatly the length of the treatment and make it much simpler. Complications, such as abscess formation and paraplegia, usually are not met with after them. Apparently they often cure paraplegia.

4. They are serious operations. Several deaths have been reported, due directly to the operation.² Death is sometimes caused by the anæsthetic. Hence, these operations should never be done without a skilled anæsthetist. The patient should always be anæsthetised in the prone position, with an arrangement of cushions under his shoulders and hips that will enable him to breathe comfortably.

5. None of my grafts has ever separated, nor have I had any serious infection, nothing but a late infection caused by a tight jacket, with the sequestration of a small piece of graft. Other operators have observed the late separation of the graft after an Albee operation. I have operated in the neighborhood of an infected lumbar abscess, and my wound has healed by first intention.

6. Opinions as to the relative merits of the two operations differ. Personally, I prefer the Hibbs operation, but it is much the more difficult. I never undertake it in the lordotic lumbar spine. It usually takes almost two hours, while the Albee operation should take about forty-five minutes, perhaps less.

²Baumann: *Cleveland Medical Journal*, 1917, xvi, 657. Patient died while being turned before operation. John: *American Journal of Orthopædic Surgery*, 1916, xiv, 450. One case forty hours after, of ether pneumonia. Wolcott: *Journal American Medical Association*. Résumé of work of others, 1916, lxvi, 110. One from shock one day after. Albee: One from fat embolus, Ryerson. Lambert: *Medical Journal of Australia*, 1918, i, 529. One next day, unknown cause. Wierzejski: *Beiträge zur klinischen Chirurgie*, 1914, xciii, 653. One case fat embolus one hour after operation, but this was with the author's modification of Albee operation. One case seven hours after operation, embolus. Gaenslen: *Wisconsin Medical Journal*, 1916, xv, 465. One case three hours after operation, enlarged thymus. Ely: *Journal of American Medical Association*, 1917, lxviii, 183.

AN EXPERIMENTAL STUDY OF BURIED BONE*

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THIS study is supplemental to one made in collaboration with Doctor John Francis Cowan.¹

The material used was obtained at a series of knee-joint resections on dogs. In some the bone fragment was buried as removed, in others it was first boiled. The bone was always buried deep in the thigh muscles of the animal from which it was removed, immediately on the completion of the resection, and the wound was sutured and dressed.

Ether anæsthesia invariable. Skin preparation of shaving, soap and water, bichloride of mercury solution, and alcohol. The wounds healed by first intention.

The animals died or were sacrificed 17 days to 1103 days (three years) after operation. The material was removed with the surrounding tissue, fixed in alcohol or formaldehyde solution, decalcified in 5 per cent. nitric acid, run through the alcohols, imbedded in celloidin (or a substitute), and stained with hæmatoxylin and eosin and with the van Gieson stain.

Following is a protocol of the experiments:

Dog 23.—975 days. Unboiled femoral condyle; diligent search at autopsy failed to discover it.

Dog 24.—694 days. Large piece of raw bone; diligent search at autopsy failed to discover it.

Dog 26.—Seventeen days. Piece of head of tibia, unboiled. Cause of death, pneumonia.

The buried bone is dead. Its lacunæ are empty. New bone trabeculæ are forming in the adjacent periosteum at part of the circumference. Live cells appear in the bone at the circumference of the buried piece in the neighborhood of the articular cartilage, and bone production apparently is beginning here also. In the interior are collections of polymorphonuclear cells, some of which stain fairly well, and give the tissue the appearance of lymphoid marrow, but no reticulum is present, and no blood-vessels. A reticulum is present near the periphery, and blood-vessels are seen pushing their way into the bone. The process of vascularization is most active in those portions of the bone that are covered by periosteum. Rarefying osteitis, typical, is going on here, but not in the interior, and here also the blood sinuses are engorged, as is customary in animals dying of infectious disease. The cartilage cells stain rather poorly, and except those close to the bone, they have lost their capsules. The basement substance is breaking up and is becoming fibrillated.

Recapitulation.—Death of bone and marrow. Formation of new bone, revascularization and rarefying osteitis at and near the periphery.

Dog 27.—473 days. Large piece of head of tibia, unboiled. The piece of bone is decidedly decreased in size, and has a definite capsule of fibrous tissue with which it is intimately connected.

The bone tissue is small in amount. The trabeculæ are scant. The cortex is thin and in places is wanting. Most of the bone is dead, but many of the trabeculæ show live

* From the Stanford University Laboratory of Surgical Pathology.

¹ Cowan and Ely: "A Study of Buried Bone," *The Journal of Orthopædic Surgery*, 1919, i, 100.

bone cells, especially near their margin—"border apposition." The marrow is about one-half fibrous, and one-half fatty. The trabeculæ, living and dead, are intimately connected with the marrow tissue. No sign of cartilage is present, but this may be due to the place of sectioning.

Recapitulation.—Decrease in size of fragment. Decrease in amount of bone tissue. Most of the bone is dead. Some is living. Fibrous and fatty marrow.

Dog 28.—374 days. Piece of condyle, unboiled. The fragment is small in size, much smaller than when buried. It does not possess a complete, definite capsule. The marrow is about one-half fibrous and one-half fatty. The two are not mixed, but the fibrous marrow occupies the middle portion, streaming in from the side not covered by cartilage. Its fibres appear to run into the bone trabeculæ and blend with them. The cartilage is in a good state of preservation, though slightly irregular in places at its surface. Fibrous tissue has also replaced its superficial portion at the sides. The cartilage cells stain fairly well, and capsules can be distinguished about most of them. The bone buttress is absent under much of the portion underlaid by fatty marrow, thick and persistent under that portion underlaid by fibrous marrow. The marrow contains blood-vessels, and shows no sign of necrosis.

The bone tissue is dead for the most part; the lacunæ are empty, but many of the trabeculæ show life at their edges, with sharply staining cells, and there are a few trabeculæ under the cartilage, lying in the midst of dead bone, whose basement substance stains sharply in contrast to that of the dead bone, and whose cells also stain. They are evidently alive.

Recapitulation.—Decrease in size of fragment. Death of bone, with some new bone deposited, especially on the margins of the dead trabeculæ. Fibrous and fatty marrow. Persistence of cartilage.

Dog 29.—1103 days. Large piece of femoral condyle, unboiled. The bone is a mere shell, and cuts easily with a knife. The bone fragment is markedly decreased in size, and is everywhere intimately connected with the surrounding tissues. It is a mere shell, and in places even this shell has been replaced by fibrous tissue. The bone trabeculæ are very few and small—mere fragments—but they are all alive. The bone cortex, where it exists, is very thin, but also alive. The marrow is exclusively fatty. The cartilage exists as three irregular islands, separated by narrow wedges of fibrous tissue. One of the lateral islands is rather thin, and its superficial portion has been replaced by fibrous tissue. Its cells stain, but many of them have lost their capsules, and the cartilage appears to be reverting to fibrous tissue. The other lateral island is somewhat thicker, and shows marked evidence of calcification in its deeper portion. Here the cells retain their capsules, but in the superficial uncalcified portion the capsules are not so well marked. The middle island is irregular in shape and structure. One side of it shows the structure of the adjacent island, and the other, of the other island. Only indications of a bony buttress persist here and there.

Recapitulation.—Marked decrease in size and consistency of the fragment. Decrease in size of cartilage. Live bone and cartilage. Fatty marrow. No sign of necrosis.

Dog 31.—922 days. Large piece of condyle of femur, unboiled. The buried bone has a well-defined capsule of connective tissue. It has not decreased greatly in size. For the most part, a thin layer of cortical bone lies directly beneath this, but in certain stretches this layer is absent, and the fibrous capsule bounds the marrow. About three-quarters of the marrow is fatty, the rest, at one end of the bone, is fibrous. Calcification is prominent in this region. The bone cells stain well. Evidently most of the bone is alive; some of it is dead. The trabeculæ are somewhat sparse. No normal cartilage is present, but a thin layer of "osteoid" tissue eroded at its surface replaces it. This contains some columns of cartilage cells and other cartilage cells in groups and singly, living and dead. A few small vessels appear in the marrow, and several engorged blood sinuses.

Recapitulation.—Little decrease in size. Trabeculæ somewhat scant, but mostly alive. No cartilage present.

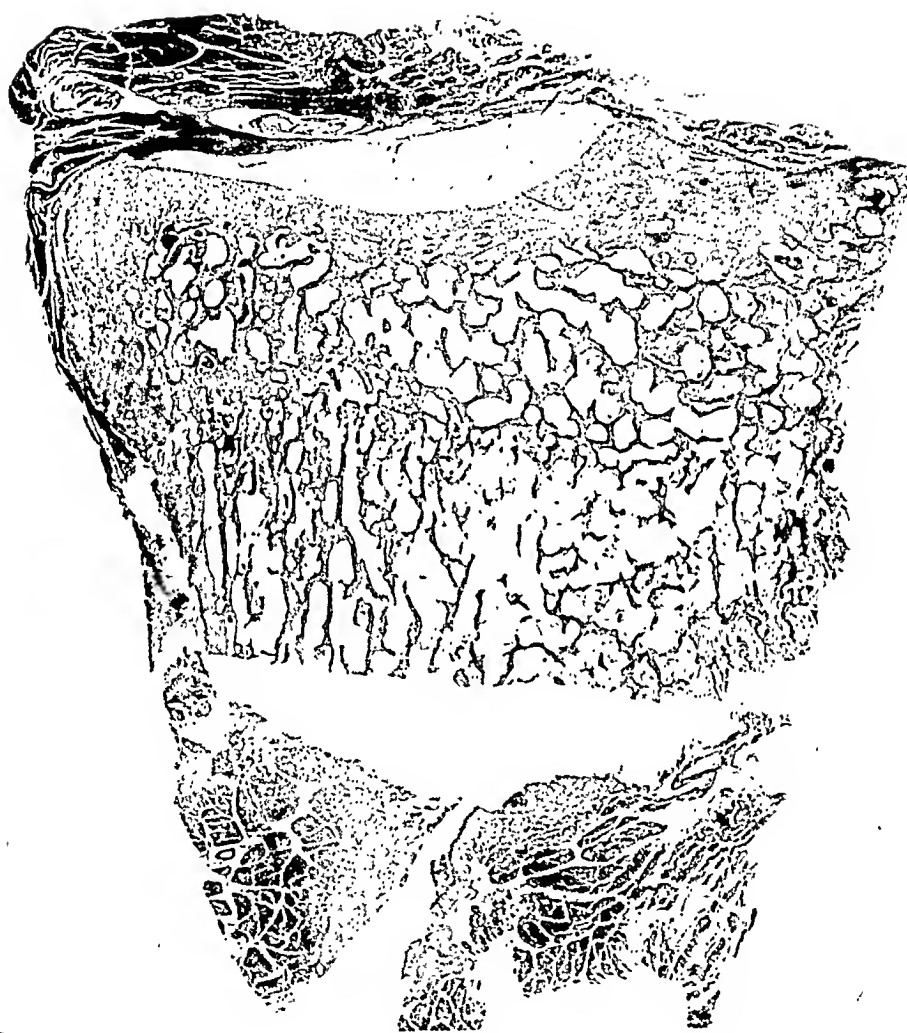


FIG. 1.—Dog 26.

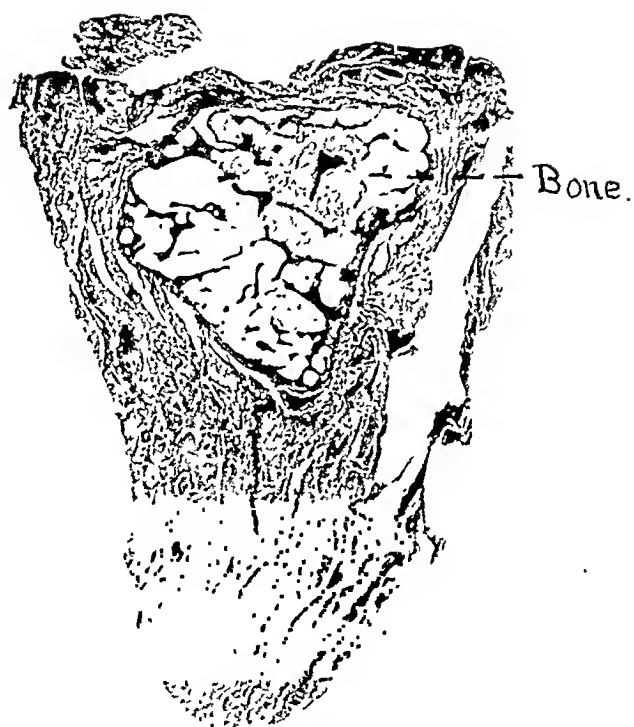


FIG. 2.—Dog 27.

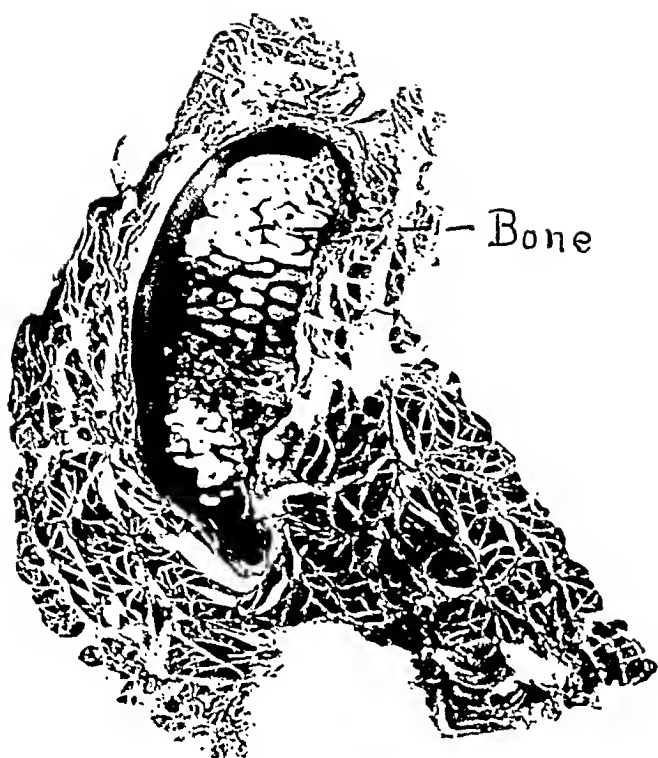


FIG. 3.—Dog 28.



FIG. 4.—Dog 29.

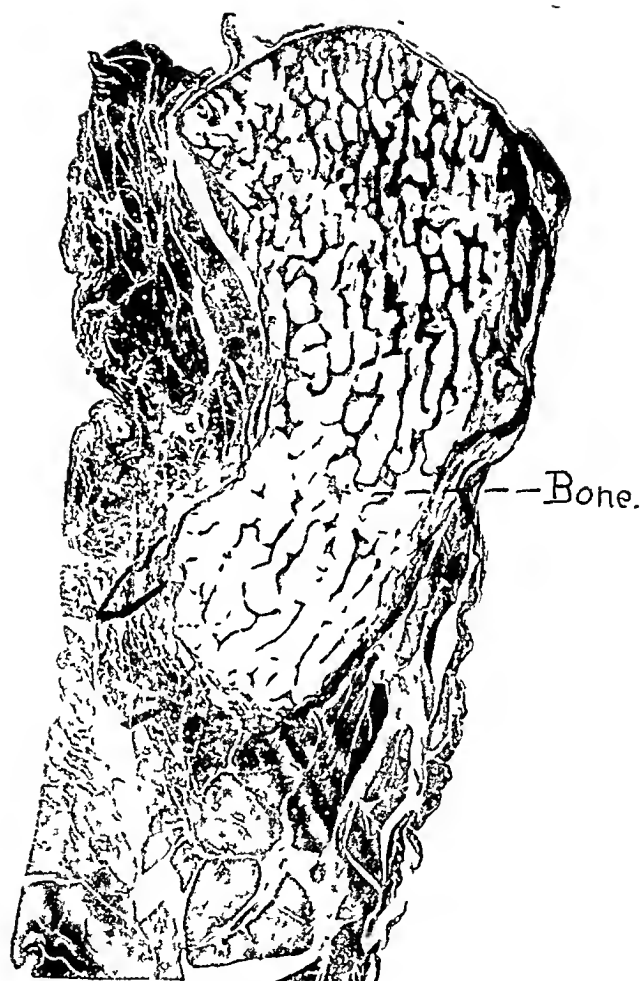


FIG 5 —Dog 31

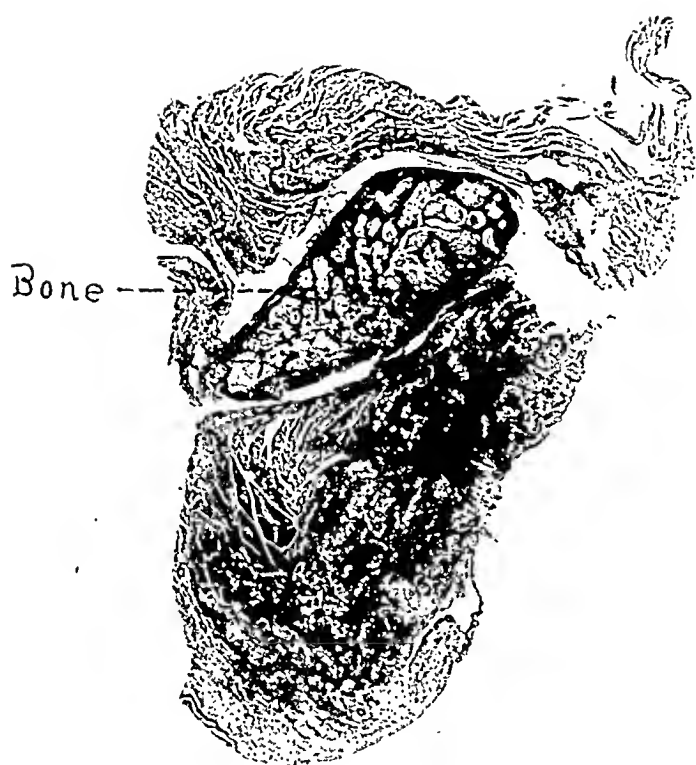


FIG. 6.—Dog 36.

EXPERIMENTAL STUDY OF BURIED BONE

Dog 32.—720 days. Large piece of boiled femoral condyle; diligent search at autopsy failed to discover it.

Dog 33.—930 days. Piece of boiled tuberosity of tibia; diligent search at autopsy failed to discover it.

Dog 35.—790 days. Large piece of boiled bone; diligent search at autopsy failed to discover it.

Dog 36.—150 days. Large piece of head of femur, boiled. The fragment is very small in size, and is encapsulated with fibrous tissue. Nothing like a cortex is present, except for a short distance. The marrow spaces are bounded by the connective-tissue capsule. The trabeculae are of about the normal number and size, but they are dead. Those at one side of the section, however, show live bone at their margins. Many of the dead trabeculae show the typical "bitten out" appearance of rarefying osteitis, but no evidence of activity is present in the process except in the part where the live bone is. The marrow is almost exclusively fibrous. One small area of fatty marrow forms the exception. No cartilage is present, but this may be due to sectioning.

Recapitulation.—Very great decrease in size. Dead bone, a little living bone. Fibrous marrow. No cartilage.

Dog 37.—544 days. Small piece of boiled tibial tuberosity; diligent search at autopsy failed to discover it.

SUMMARY

Twelve experiments, 7 with raw bone, 5 with boiled. Of the 7 with raw bone, in 2 the bone could not be found, one after 975 days, one after 694 days.

Of the 5 with boiled bone, in 4 the bone could not be found, one after 720 days, one after 930 days, one after 790 days, one after 544 days.

In the 5 other experiments with raw bone, the fragments were recovered after 17 days, 473 days, 374 days, 1103 days, and 922 days.

In the other experiment with boiled bone, the fragment was recovered after 150 days, but it was very small.

In other words, no boiled bone was recovered after 150 days, while raw bone in one case persisted for 1103 days—3 years, 7 days. *Raw bone resists absorption better than boiled bone, but it also is slowly absorbed.*

A decrease in size of the fragment was almost invariable. Generally, also, it decreased in density—exception, one boiled piece.

Generally the conclusions reached in the former study are confirmed, but this series indicates, in addition, that the bone and marrow in the buried fragment both die. The marrow is then re-formed by blood-vessels pushing in from the surrounding tissues, and a certain amount of new bone is laid down upon the old, especially along the margins of the trabeculae. The cartilage usually lives, but slowly becomes eroded at its surface, and becomes thinner. Its buttress soon disappears.

Dog 26 shows well the influence of the periosteum in bone formation. The periosteum does not "form" bone, but bone is formed in it. The portion of the dead bone adjacent to it is more quickly vascularized and hence is earliest the seat of new bone formation.

NOTE.—The illustrations are all low-power photomicrographs, magnified 5 diameters. This gives an idea of the decrease in size, with Dog 26 as a standard, though, of course, no attempt was made to measure the exact size of the fragment when it was imbedded.

THE SELF-RETAINING SLIDE BONE GRAFT*

BY HARVEY C. MASLAND, M.D.

OF PHILADELPHIA, PA.

POSSIBLY no field of surgery in recent years has shown more brilliant achievements than have been obtained in plastic bone work. A perusal of the literature accumulated in the last five years demonstrates that from the earlier apparently contradictory explanations of bone regeneration there has developed a more definite comprehension of the rôle of the periosteum and of the osteoblasts and osteoclasts. Their activity has been studied in both the resident and the implanted bone. Gallie and Robertson have appealed to me as giving a logical and plausible explanation of the regenerative process. In condensed form, the degree and rapidity of regeneration depends on: the close contact of the bones, the number and vitality of the osteoblasts, and the opportunity offered for the continued subsistence of these osteoblasts.

In recent fractures where the osteogenetic functions of the ends are sufficient with coaptation to produce union, they believe a boiled bone plate as satisfactory as an autogenous plate. This expedites the operation and eliminates structural weakness in the bone from which the autogenous plate is taken.

It might be remarked here that the open operation for fractures should be used only when the older standard methods do not promise a good result.

My experiments, using a bone plate and bone screws and either a surface contact or a partial inlay on the fractured bone, gave a good mechanical result and in selected cases should give a good final result.

It is my thought, however, to consider the suggestions that these men and others have offered that make for the success or failure of plastic bone surgery, and apply them to the self-retaining slide graft procedure:

First, in plastic bone surgery the need of faultless aseptic surgery is absolute. This applies to the hands. It may be that a glove can be as sterile as an instrument, but if the operator trains himself not to touch the bone with his hands, it will have a salutary effect on other details.

All traumatism should be eliminated as much as possible. This can be accomplished best by a power-driven bone-cutting equipment. All the bone cutting necessary is done without force, with accurate control and minimum wastage.

The bones should be made to contact with the highest possible degree of accuracy. The vitality of the contacting surfaces is of the highest degree of importance. It is unfortunate that the universal motor, so ad-

* Read before the Section on Surgery of the Pennsylvania State Medical Society, September 25, 1919.

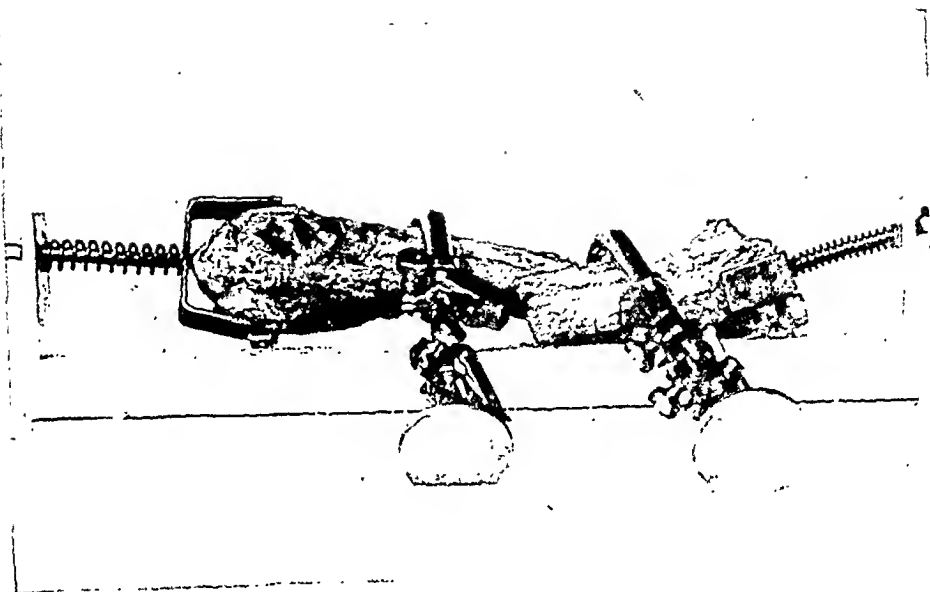


FIG. 1.

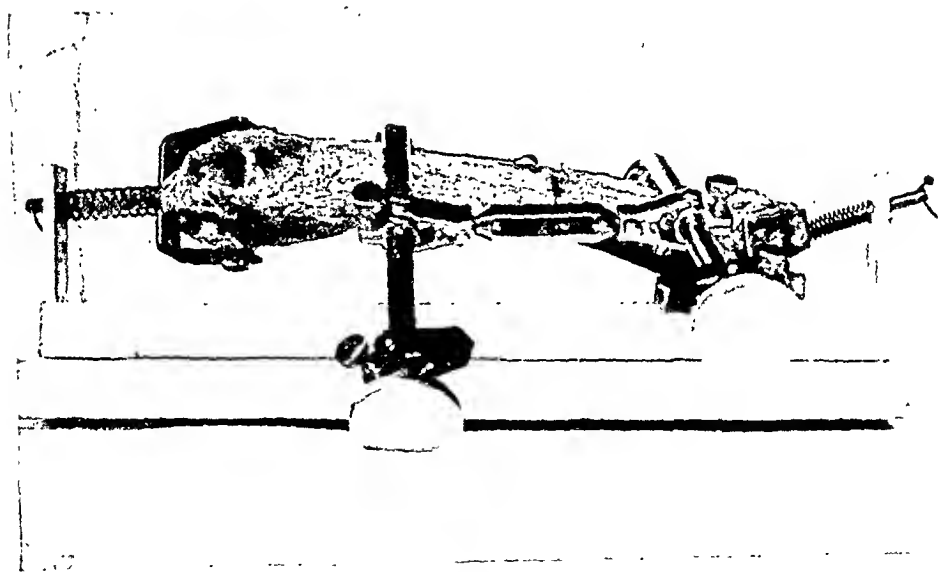


FIG. 2.

SELF-RETAINING SLIDE BONE GRAFT

vantageous in other respects, rotates the circular saw at such high speed that carbonization of the bone is inevitable without a constant drip. A low speed motor, though handicapped in that it must be used for the direct or alternating current individually, is preferable because it eliminates burning and so preserves the life of the contacting osteoblasts.

The bones should be held as rigidly as possible. Absorbable sutures, which are the only kind recommended for this purpose, will stretch and allow play in the jointing. Where bone pegs alone are used and hold by virtue of being forced in, the pressure may cause atrophy and lessen the vitality of the region involved. Further, they can slip before the repara-

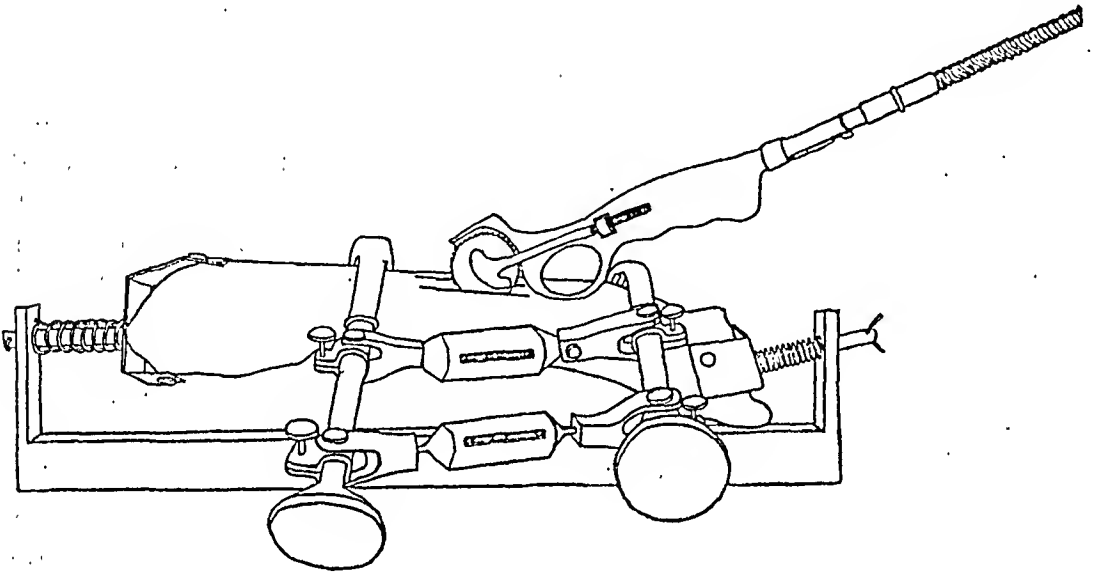


FIG. 3.

tive process has advanced sufficiently to nullify the consequences of their giving way. Logically, then, the bone screw is most desirable. It turns in readily, presents a larger surface for osteogenetic repair, and cannot slip. This paper is not considering the subject of metallic plates, wires and screws. Their only excuse to-day is that the facilities are not at hand for doing better work.

Bone plates, screws and pegs, either autogenous or heterogenous, and chromicised gut will meet all the demands, and being absorbable will not give the proportion of subsequent complications.

The surgeon should be prepared at the time of operation to do a bone plating, either partially inland or after the more common Lane method, or some slide graft procedure. The decision would depend upon the site of the fracture and the size and conformity of the bones as to the method chosen.

The difference between the self-retaining and the ordinary beveled graft is that the bevel is cut in opposite directions. In the self-retaining graft the saw undercuts the wall of the remaining bone shaft. Its advantage is that the wall of the shaft prevents the graft from springing out.

While the ordinary plate can be lifted out readily, the self-retaining plate must be dislodged and slid along within the course of the gutter. This is not as difficult as one might think. The cut is made twice as long on one side of the fracture as the other. Not less than one inch on one side and two inches on the other side should be made. During the operation the replacement clamps are holding the fractured ends in position. If the shorter graft cannot be tilted and removed, a flange on one side can be cut off and the plate readily slips out. This short graft can be sliced and used for bone screws. Not infrequently the bone is too thin to make a good screw. It is my belief that heterogeneous boiled screws and pegs will answer, and it is advisable to have them at hand. This does away with the necessity of attacking the tibia for additional bone.

The ordinary beveled graft, if sutured in place, will inevitably spring somewhat from its seat, as the greatest strain is resisted by the sutures alone. If bone screws are used they must be passed through the medullary canal and threaded into holes into the compact bone of the opposite side. Oblique holes through the bone cannot be threaded unless the entrance be countersunk and this weakens the bone where strength is most required.

In the self-retaining graft the shaft wall prevents the graft from coming out. To keep it up against the shaft gutter, two holes are drilled and threaded directly through the graft toward each end, one on each side of the fracture. Bone screws are inserted and passing through the medullary canal impinge on the opposite compact bone of the shaft. By continuing to turn the screw after it hits the opposite compact bone the graft is forced upward until it is tight against the gutter wall. Oblique holes are drilled through the side walls of the shaft catching the graft at its lower edge. These act as shelves supporting the graft in position and preventing sinking in. As the strain is not in a direction to force them out, they do not have to be forced in, but just a snug fit.

I have made a number of photographs showing the different stages of the operation. A bone mounted to simulate a fracture gives opportunities for better views.

Figs. 1, 2 and 3 show the replacement clamps reducing the fracture and holding it in accurate position for the subsequent manipulations. The specially new feature of this clamp is the universal joint connection of the separating mechanism, with the clamp shaft. This permits any movement necessary to bring the bones into perfect position. By tightening a few wing nuts the clamps are made rigid in their final position.

Recent fractures usually do not require much force for replacement, but in any case the clamps serve a useful purpose in preventing the fragments from continually slipping during the manipulations of permanent fixation.

The circular saw shown in Fig. 3 cuts with the accuracy and control of a scalpel. The trim cut without waste possible with a circular saw,

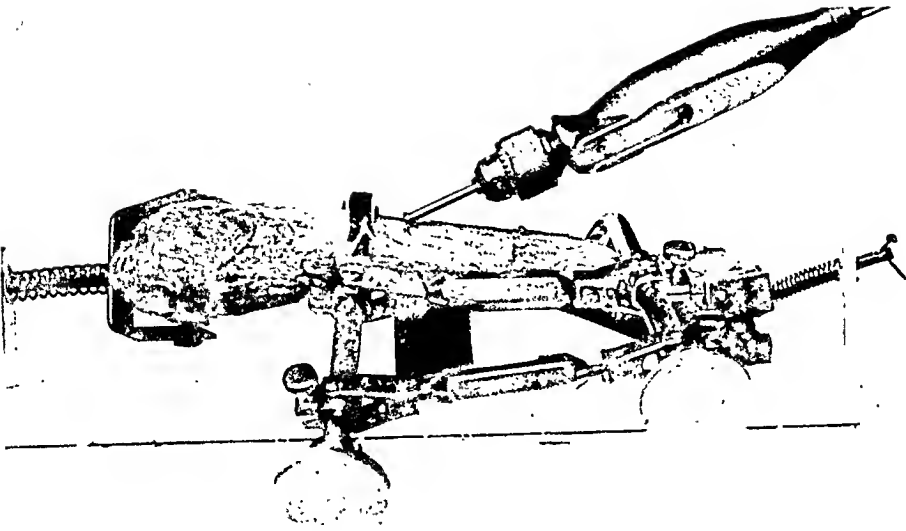


FIG. 4.

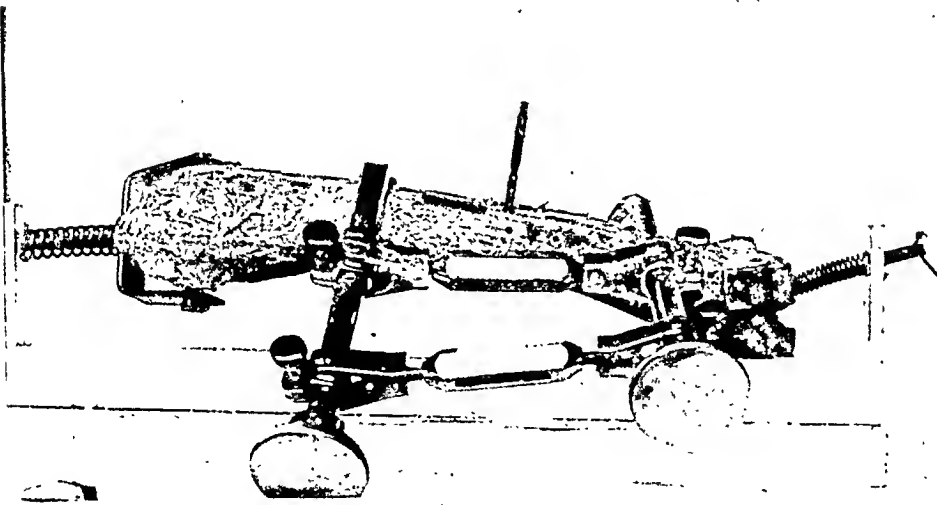


FIG. 5.

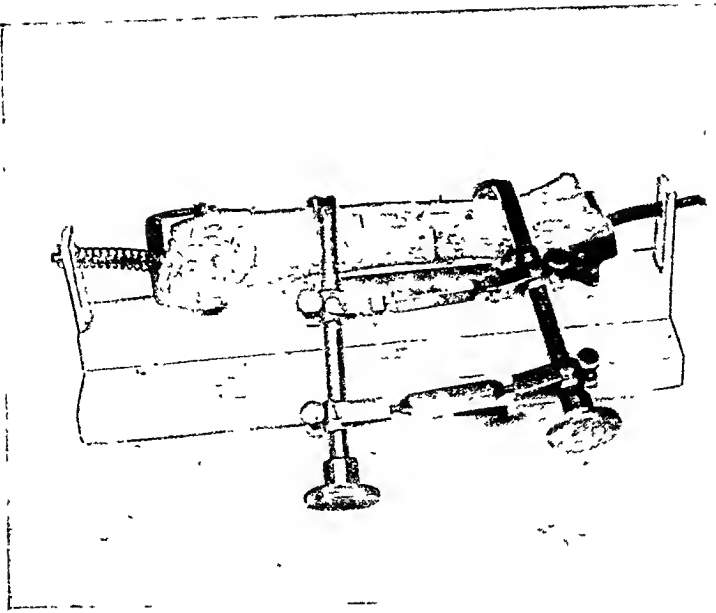


FIG. 6.

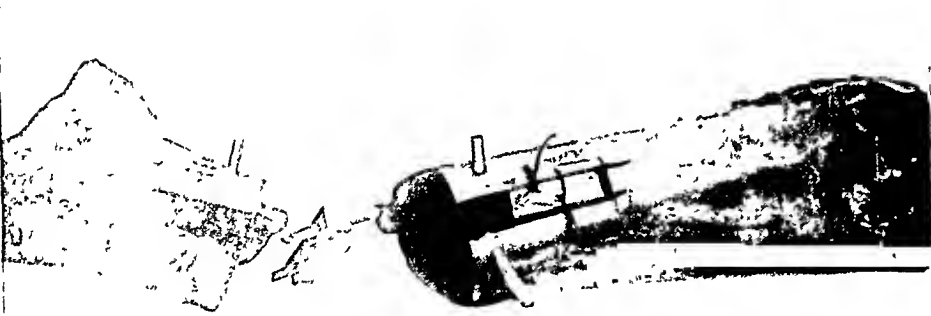


FIG. 7.

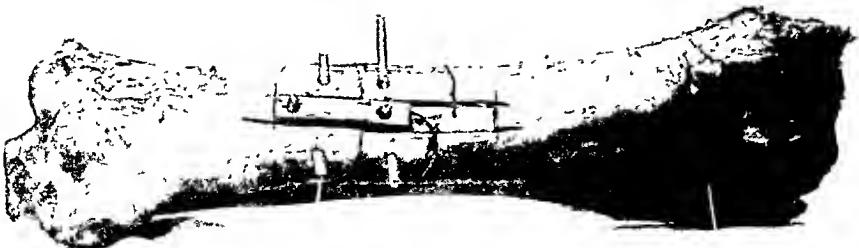


FIG. 8.

SELF-RETAINING SLIDE BONE GRAFT

and its quickness of execution are sufficient recommendations for its universal adoption.

Other tools now provided working with reliability and accuracy practically bring a machine shop to the operating table.

The other illustrations with the explanations that have been given and the footnotes do not need further comment.

In operating, the anticipated steps of the procedure should be carefully planned so that the various tools are not needlessly rehandled and the element of time is conserved.

It will be seen that in this method the advantages are that the bones are brought into good alignment. There are no sutures to slip. No metallic material is present. The bone grafts cannot slip. The strength of the graft plus its bracing is the index of the strength of the jointure. The requirements laid down for the greatest likelihood of regeneration and union are adhered to.

THE USE OF METALLIC FIXATURES IN SECURING BONE FRAGMENTS

PRESSURE ANALYSIS AND A NEW METAL BONE BOLT

By WILLIAM LISLE BELL, M.D.

OF OAKLAND, CAL.

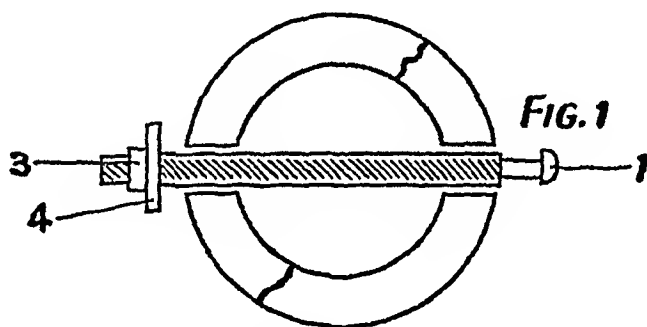
DESPITE the recent revolution against metals, many operators continue and will continue their use, and will be for some time unequipped with the intricate devices necessary for all autogenous work.

The methods of Albee and his contemporaries offer to most of us a nearer approach to the ideal. Autogenous work is promised a wider acceptance when more men become equipped and technically familiar.

In the interval many surgeons will adhere to metallic fixtures, and it is with a desire to simplify some of these methods as well as to place particular emphasis on devitalizing crushing metal pressures, that these arguments are put forth.

Many still adhere to the methods of Lambotte, and in spirals, or obliques, where the bone, if laterally held, is self splinting, use some form of through and through fixture.

The bolt answers these requirements.



The objection has been that the nut must be placed on the deep end, and the bolt measured and cut first or later cut with difficulty and at an improper angle.

The space needed for these manipulations in the deeper tissues entails undue trauma and loss of time. Trauma may be lessened and time shortened with the quick locking bolt now to be described.

The bolt is shaped as illustrated in Fig. 1.

Modus.—1. Incision and reduction.

2. Clamp bone in accurate approximation.

3. Drill through both sides, large enough to admit bolt head No. 1.

4. Nut and washer Nos. 3 and 4—Fig. 1—are not removed from bolt.

5. Bolt inserted through drill hole head first—i.e., with nut proximal to operator.

METALLIC FIXTURES IN BONE FRAGMENTS

6. Split washer—Fig. 2—is held by any properly curved light forceps, with a small longitudinal groove filed on the inner side of the blades at the point. Lock nut, Fig. 2, now slipped over inner bolt end, as in Fig. 4, No. 5.

7. Bolt now drawn firmly toward the surgeon locking the inner end automatically as in Fig. 5, No. 6.

8. Nut turned up till washer just touches and projecting end cut on the accessible outside.

9. Efficient, sterilizable bolt cutters at any hardware store. No special instruments, not even screw drivers, needed,



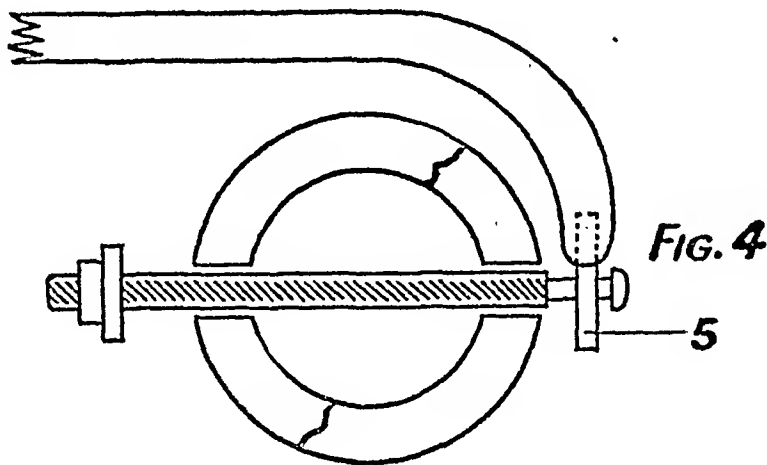
Technical Advantages.—1. Short incision, brief anæsthetic.

2. Holding surfaces large enough to absorb stress.

3. Little bone periphery constricted.

4. Excellent holding equation against rotation, side slipping, and angulation in one, sometimes all planes.

5. In bolting where both sides are approachable through a stab wound, the older plain bolt answers fully as well.



Long transfixing screws in many places do not hold as dependably as bolts, and unless very carefully placed and self-reaming, impose an expansive force, and if too vigorously tightened, a contractile stress which very soon means loosening from surrounding bone.

These pressure remarks apply to all screws or vise-like arrangements, with or without plates.

The screw when forcibly tightened is making a violent and continu-

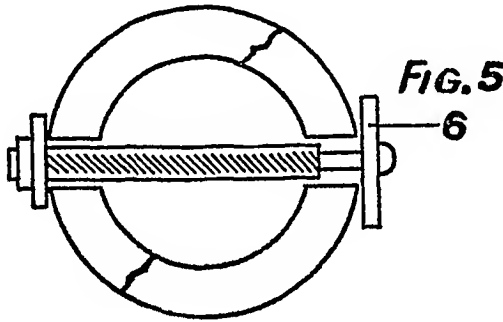
ous crushing effort to extricate itself from the bone and if the stress is maintained long enough and violently enough, it always succeeds.

The surgeon who has not experimented has little conception of the violent crushing exerted by a small screw when working against a wall of steel, or two opposing fragments of bone, or of the expansive force exerted when a tapered screw is driven home.

Albee has shown us some excellent examples of this in his volume. If the X-rays of plate failures are closely inspected, it will be observed in many that not only has the screw *killed* the bone directly encircling it, but that the plate was compressed violently enough against the compact layer of bone to produce pressure absorption for almost the entire under surface of the plate.

To a degree the avoidance of this condition is simple.

Use (if you must) a machine or parallel-sided self-tapping or cutter-pointed screw.



With a drill hole of sufficient size, turn the screw slowly forward half a turn, backward a quarter turn, and so onward until seated.

This screw cuts rather than wedges its way into the bone.

The compression pressure is avoided by seating the screw until it just touches but does not compress the plate. The plate should be more convex than bone surface, and should be slightly bowed to avoid pressure at fracture surfaces.

Bone levers, prys, spatulas should be avoided, for in prying and wrenching of fresh bone ends much periosteum may be separated and driven back. The many tables now on the market furnish an excellent means for most *operative* extension, and with slow intermittent pull, irritable muscles may be fatigued in a way to extend without violent saddle pressure, ankle or knee pull.

Pressure, to my mind, has never been sufficiently emphasized, and it is probably the most outstanding cause for premature loosening, infection, and malposition.

I have watched this work impartially in the hands of hundreds of men in many lands and a faultless technic cannot be too strongly enjoined, but a so-called faultless modus becomes faulty indeed when at the very heart of

its faultlessness, lies a strangled and crushed bone. We are facing these days two diametrical schools, the one ultra-scientific, the other ultra-mechanical. Both are invaluable when reciprocal, both a fine art, but the mechanical without gentleness and infinite care presents dangers.

A third source of dangerous pressure I have been unable to find in print. It is the placing of a plate on fractured ends in slight overextension or separation. This brings the full approximating force of fragments against screw sides. This may be done through overextension or inaccurate rotation placement, with subsequent slight slipping.

In this respect, the larger *bolt* with its prevention of rotation, larger softer surfaces which prevent spreading, its freedom from expansive pressure, and easily avoided vise action (except what is unavoidably imposed by the fragments themselves) offers a much more ideal fixture than the plate and screw. Where the fracture is at all spiral or oblique, and not too comminuted, a loop of gut or other absorbable material may be thrown over the bolt ends and loose fragments lashed down without completely encircling the periosteum.

Fracture surfaces, wherever possible, should stand on their own ends, *without anything but a decided minimum of super-imposed trauma.*

Résumé.—1. No created *pressure*. Let the internal splint act as purely a *holding device*, not a crushing device that imposes many times the requisite amount of *force*.

2. No overburden or increased trauma—no prying, wrenching, and tearing away of periosteum, with pinch bars.

3. Dry incisions on closing.

4. Gradual and intermittent extension with *heavily* padded saddle. Minimum perineal pressure, ankle and knee pull.

5. Compression at fracture area, metal gauze sub-splint (see more refined apparatus (Hennequin), Dehelly and Lowey, *ANNALS OF SURGERY*, April, 1919, page 367).

6. No suture pressure in fascia. It will cicatrize or approximate later if not infected.

LEFT BRANCHIAL CYST OPENING ON THE RIGHT SIDE

BY ADDISON G. BRENIZER, M.D.
OF CHARLOTTE, N. C.

CASE I.—A young man, nineteen years old, first noticed a swelling on the right side of the front of his neck, below the Adam's apple, in December, 1918. The swelling was lanced by his physician and extruded a yellowish slimy substance. The incision partly closed, but continued to run. In February of this year he was taken to a surgeon, who opened the swelling the second time and scraped it out. Again the incision partly closed, but the discharge continued. In April the surgeon operated, dissecting and scraping out the surrounding tissue, but the result was ever the same; it continued to drain.

The patient presented himself with the right lower side of his neck considerably scarred, with a fistulous opening discharging a thick mucous pus. A curved incision was made, from left to right, across the neck as for a thyroidectomy, similar to the Kocher collar incision, but allowing the incision to divide over the right of the neck, so as to encircle the cicatrix and the mass. The skin flaps were dissected upward and downward. With the area of scarred skin left attached, the enlargement, *en masse*, was dissected out and traced, from right to left, upward across the sternohyoid muscles and thyroid cartilage, under the anterior belly of the omohyoid muscle and along the deep vessels of the neck up to the hyoid bone. On crossing the midline of the neck, the mass became attenuated into a fistulous tract, open, however, and admitting a probe up to the hyoid bone. The skin flaps, with platysma muscle, were brought back over the neck and closed, with a small tape drain in place. The drain was removed after forty-eight hours and the wound healed *per primam*. This was three months ago and since that time I have seen the patient frequently and found his neck healed and smooth.

Diagnosis.—Left branchial cyst opening on the right side.

Of the four branchial clefts and intervening branchial arches in the four weeks' foetus, only the first cleft should persist, forming the hyomandibular cleft, from which develop the ear, auditory canal, Eustachian tube, etc. The other three should coalesce in foetal life, leaving the neck smooth. If closure does not take place, these clefts persist as congenital formations, known as branchial cysts or fistulæ.

These fistulæ may (a) Open into the pharynx and, at the same time, open on the skin; (b) they may open only outwardly; (c) they may open only inwardly; or finally, (d) they may have neither outer nor inner opening and may thus persist as blind fistulæ. These fistulæ may persist as

LEFT BRANCHIAL CYST OPENING ON THE RIGHT SIDE

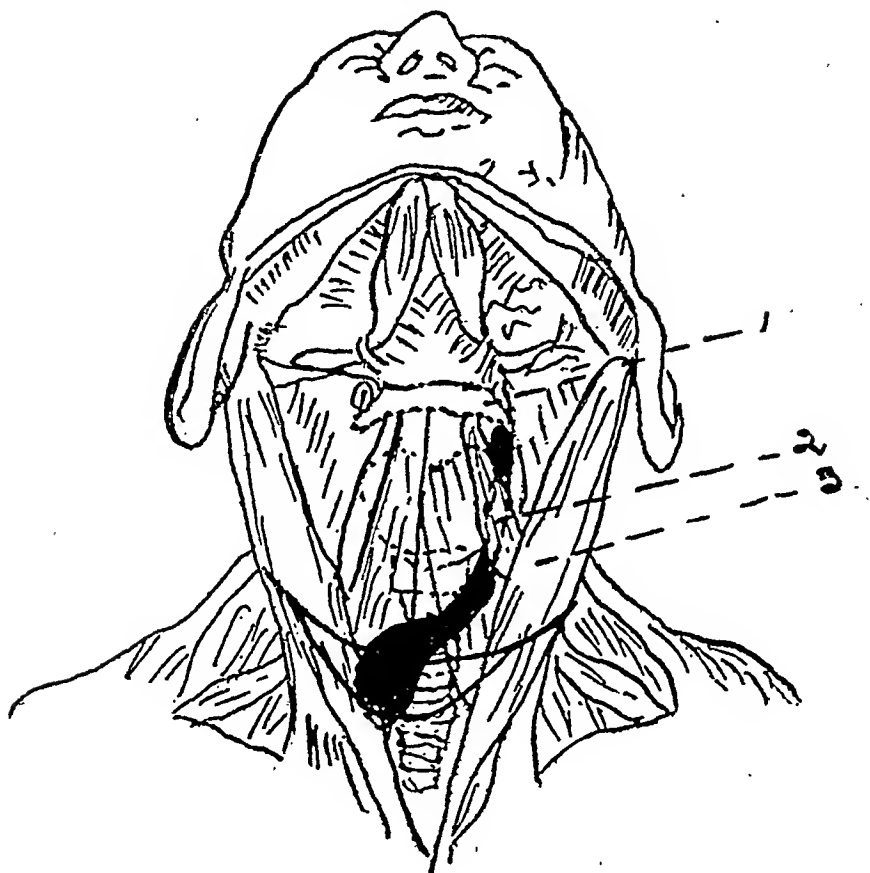


FIG. 1.—Diagram of the cyst, projected to the surface, along with the thyroid cartilage and trachea. (1) Hyoid bone; (2) omohyoid muscle; (3) sternomastoid muscle.

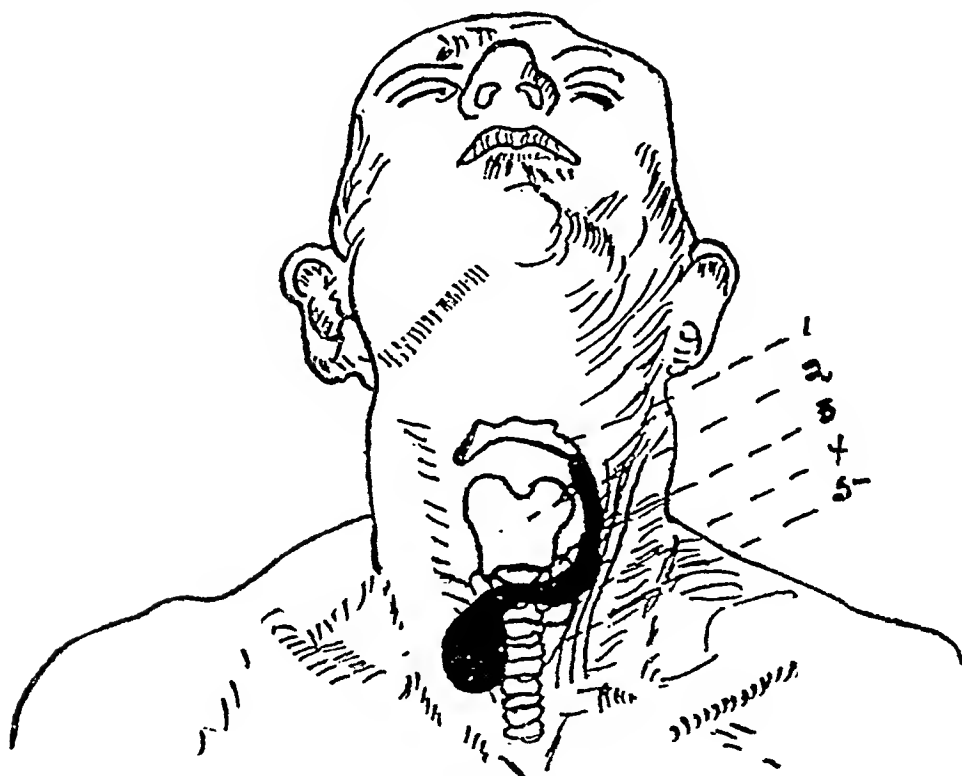


FIG. 2.—Showing the cyst in relation to the musculature of the neck. (1) Hyoid bone; (2) thyroid cartilage; (3) cyst; (4 and 5) internal jugular vein and carotid artery.

mere tracts, lined by hypoblast within and epiblast without, separated by a layer of mesoblast.

My case was of the last type, having neither outer nor inner opening and persisted latent and not making itself known from foetal life to the nineteenth year, at which time it likely became cystic through the cellular activity and secretions of its lining cells, aided by infection and pointed on the right side of the neck. Sebaceous cysts, we know, commonly behave in this way.

Branchial fistulæ or cysts usually open on the same side where they take origin. The explanation why this left-sided cyst opened on the right side might be made in two ways. First, and the more probable: As the cyst increased in size and weight through the accumulation of secretions, by gravity and by virtue of fluid pressure, it pushed its way down the left side of the neck, to be turned across the midline to the right side by the anterior edge of the left sternomastoid muscle. Second, and less likely: There may have been persisting an anlage of a fistula on each side of the neck, a short lower end on the right, with a coalescing across the midline.

This case is interesting through several facts, namely: that the branchial fistula persisted for nineteen years before it became cystic and made itself known; that it pointed on the opposite side; that it was thrice previously operated on, and that the condition was cured only by its recognition and its complete dissection and removal.

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A MONTHLY REVIEW OF SURGICAL SCIENCE AND PRACTICE

EDITED BY
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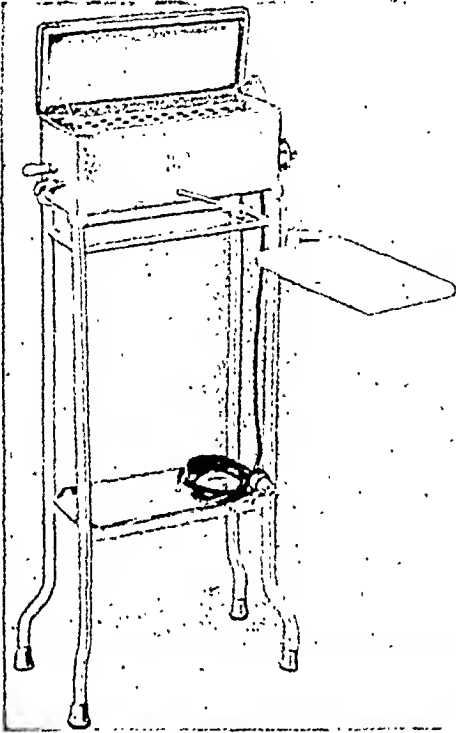
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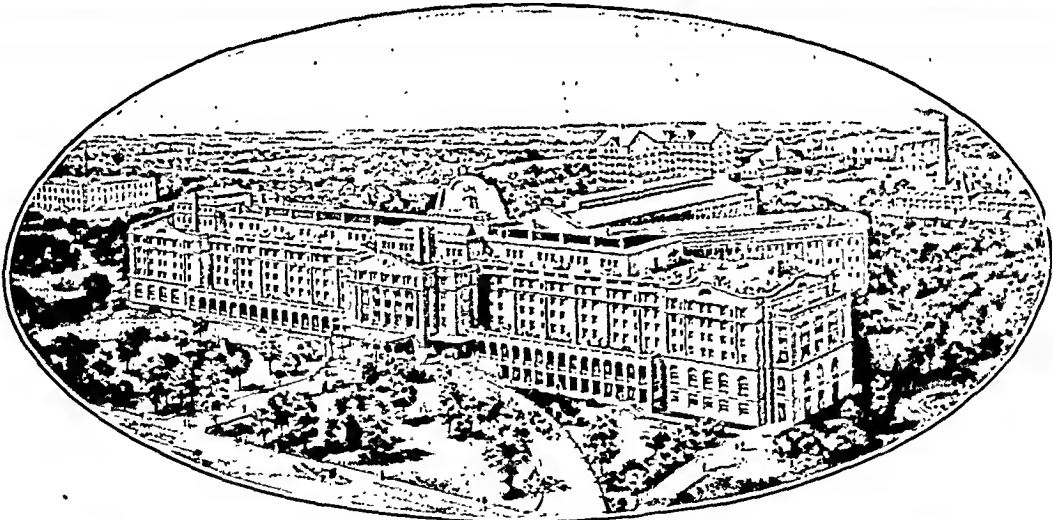
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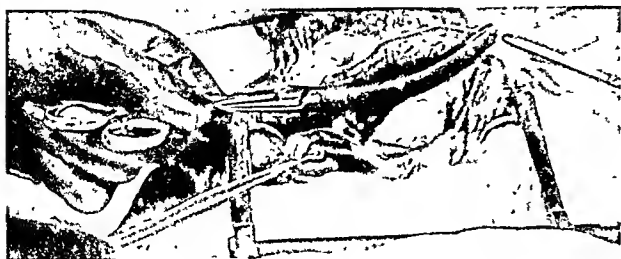
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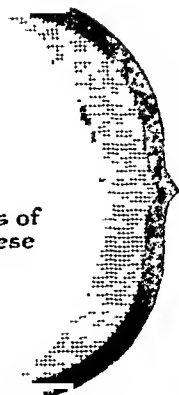
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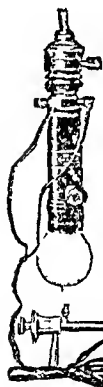
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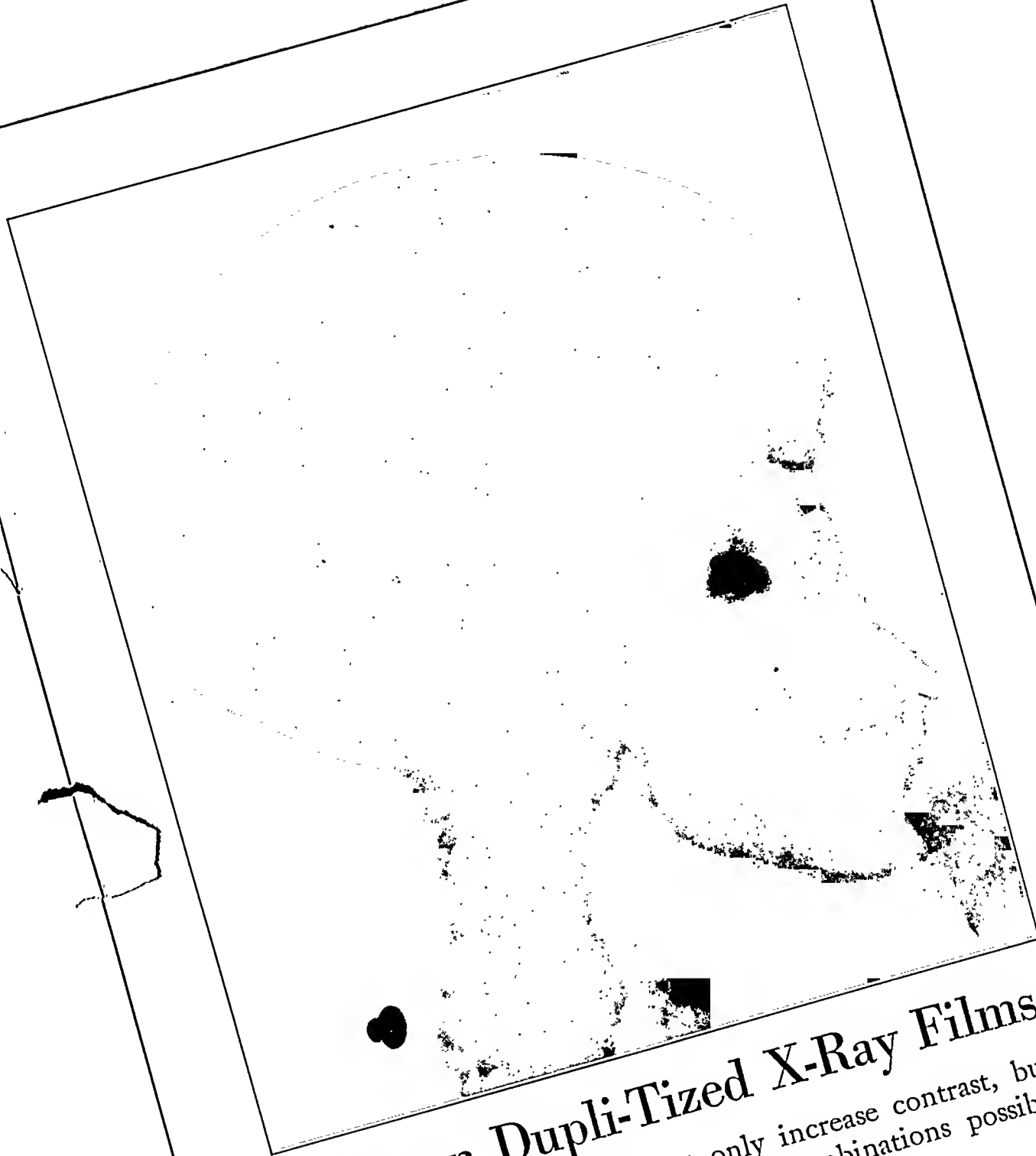
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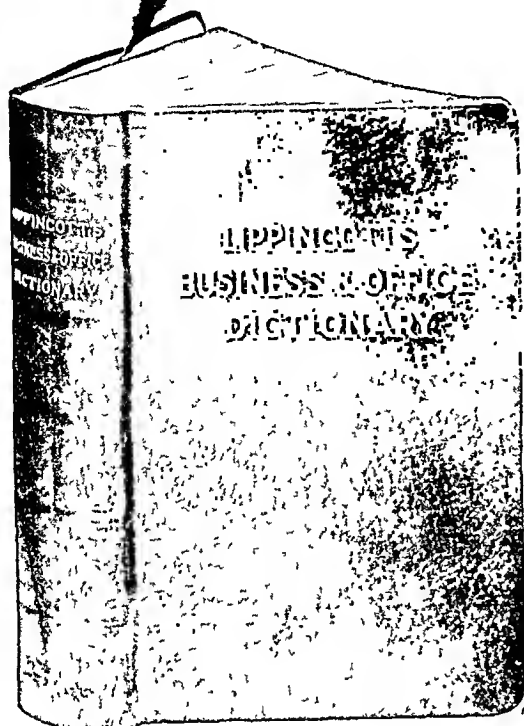


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